Materials Engineering in Product Design & Manufacture

Materials & Methods

March 1954

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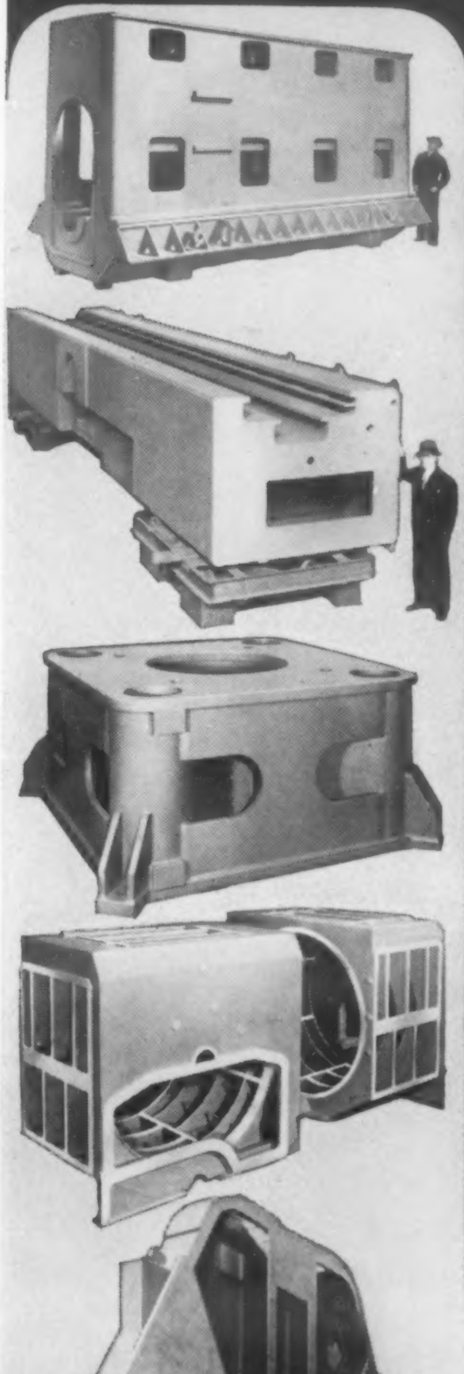

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FEATURE ARTICLES

MATERIALS & METHODS MANUAL NO. 103

ENGINEERING FILE FACTS

DEPARTMENTS

The Materials Outlook

METAL SUPPLY

The amount of the three primary metals set aside at the mills for military and AEC purposes will be significantly less in the next quarter than in this quarter. Reflecting recent cutbacks in arms output plans, the Office of Defense Mobilization has asked for 13% less steel, about 30% less copper, and 15% less aluminum.

STEEL PRICES

Base prices for steel are pretty firm right now, but you can expect some reductions on "extras". Most important recent trend has been toward lower extras on drawing quality sheet.

ZINC

Price of zinc has sagged to 9¼ cents a pound . . . Domestic zinc refiners have announced sharp cuts in output in recent weeks . . . Meanwhile, several western senators met recently with the President to promote relief of "distress conditions" in the lead and zinc mining industry.

COPPER RECOVERY

A new plant for the separate recovery of copper, tin, lead and zinc from copper scrap is expected to be in operation in a few weeks. It will use a chemical process claimed to bypass the traditional refining step needed to separate the metals from melted-down scrap.

STOCKPILE METAL PRICES

Buyers of columbium and tantalum can no longer get it from the government stockpile at current market prices. From now on customers will have to pay what the government paid for it --namely twice the market price (the price paid by the government to encourage production of these scarce metals).

MORE NICKEL

In an attempt to boost nickel production, the government recently awarded fast tax write-off privileges to Nicaro Nickel Co., a subsidiary of Freeport Sulphur Corp. It will spend $35 million on mining operations in Cuba, and $18 million on a pilot processing plant near New Orleans designed to test a new process for extracting nickel and cobalt from the Cuban ore. Meanwhile, National Lead Co. will undertake a $43 million expansion of the government-owned plant it operates at Nicaro, Cuba. This expansion is expected to boost annual plant capacity of 28 million pounds by about 75%.

(Continued on page 4)

The Materials Outlook *(continued)*

TITANIUM

The government has created a special committee within the ODM to determine defense needs for titanium and to arrange a timetable for its production. The move developed from increasing concern in official quarters over what would happen if aircraft production had to be stepped up to a wartime level now. . . . One of the principal titanium producers has announced price reductions averaging 12% on mill products.

STRONTIUM TITANATE

Strontium titanate is being grown in single crystal form by the flame fusion method. A clear, colorless, isotropic material with high refractive index (2.409), high dispersion and Moh's hardness of 6.0 to 6.5, it is expected to have optical applications. Although it is not ferroelectric, its high dielectric constant (310) and close relationship to the ferroelectric compound, barium titanate, may lead to specialized electronic applications.

TRENDS IN PLASTICS

Pressure bottles and cylinders molded of epoxy-glass reinforced plastics are now being used at working pressures up to 3000 psi. . . . A new and promising anti-static coating for plastics is reported under development . . . Plastic tooling is a rapidly growing application with epoxies, in particular, attracting great interest . . . Good mechanical and electrical properties are resulting in increasing use of compression- and transfer-molded parts made from glass-polyester premix. . . . Cost figures assembled by Corvette engineers show reinforced plastic bodies produced by matched metal die molding cost less than metal bodies up to a production volume of about 15,000.

NEW SUPERALLOY

The recently announced superalloy, GMR 235, is claimed to meet gas turbine creep and yield requirements while operating more than 100 hr at 35,000 psi and 1500 F. Containing no cobalt or columbium, the alloy consists of 65% nickel, 17 chromium, 6 molybdenum and lesser amounts of aluminum, titanium, boron and other elements.

PLATED POLYSTYRENE

Revived interest is being shown in a technique for plating polystyrene, developed during the war, that results in exceptionally good adhesion where metal thickness does not exceed 0.003 in. The method utilizes a copper or silver conductive undercoat; any metal that can be deposited electrolytically on these metals can be used provided solution temperatures over 185 F are not required. Current interest seems to center on the possibility of printed circuits made by printing circuits directly on the polystyrene base and plating to the desired thickness with no etching needed.

Experimental design studies by major manufacturers, such as the Cadillac Sports Coupe above, have captured interest of engineers and public alike. Low cost of lay up molded bodies allows manufacturers to test public reaction to new styling at minimum cost. Plastic bodied cars were major discussion topic at recent plastics shows.

Plastics Meetings Present

New Technical Developments

With 1954 still young, two of the year's most important plastics meetings are already history. Both meetings had their usual share of rosy optimism, but both were also marked by publication of some significant technical developments. The Society of Plastics Engineers held their annual meeting in Toronto the end of January. The Reinforced Plastics Division of the Society of the Plastics Industry held its annual exhibit and conference in Chicago the following week.

Perhaps the most significant paper delivered at the SPE meeting was given by E. E. Ziegler, of Dow Chemical Co., on "Crazing of Polystyrene." Ziegler and his associates developed new testing equipment and techniques which enabled them to learn critical elongation values for polystyrene in contact with many different chemicals and under conditions of widely varied times, temperatures, internal stresses and degrees of orientation. Under many conditions, critical stresses in polystyrene appear to be much lower than heretofore generally suspected. Proper application of this kind of knowledge can do much to prevent user dissatisfaction with polystyrene parts in the future. (M&M will publish an article based on this paper next month.)

Epoxy Copolymers

Another paper of more than routine interest described the properties of products obtained by copolymerization of epoxy resins with polysulfide liquid polymers. According to J. S. Jorczak and J. A. Belisle, of Thiokol Chemical Corp, the resulting material has lower shrinkage, lower strain, greater and permanent flexibility, much higher impact resistance, lower moisture vapor transmission, lower pouring viscosity and better peel strength, compared to the epoxies alone.

Two speakers stood back and took an overall look at the plastics industry. Their conclusions put emphasis in somewhat different places. A. Renfrew, of Imperial Chemical Industries, Ltd., England, believes there will be "no spectacular new plastics until a radically new approach has been made." He sees a trend toward "quality, uniformity and standardization." Other trends are the finding of new applications and the improvement of fabricating techniques.

To H. A. Gadd, of Canadian General Electric Co., what the plastics industry needs most is "less empiricism and more science." He would like to reverse the present ratio of "75% art, 25% science." This can only be done, he says, with documentation of experience, penetrating analysis, and application of resulting laws and facts coupled with ingenuity and creative thinking.

Arcs Beat Phenolics

A reminder that the material that was good enough yesterday may not be good enough for today's more severe conditions came from Thomas

(Continued on page 210)

Conference will Feature High Temperature Materials

The peacetime industrial use of high temperature materials developed in conjunction with rocket and jet motor research will be a major discussion topic at the Basic Materials Conference in Chicago. Superalloys, cermets and protective coating techniques will be examined in terms of industrial applications which can improve product performance, cut costs, and lengthen the life of parts subjected to the temperatures and stresses encountered in modern high performance powerplants and processing systems.

Other conference sessions will cover such topics as the establishment of a materials department in a manufacturing concern; recent development of new materials; metal forming processes; the use of corrosion and erosion resistant materials; adhesive bonding of metals and plastics; and the development and use of non-metallic engineering materials.

Concurrent with the Materials Conference, the Second Basic Materials Exposition will display thousands of materials available to manufacturers. Displays are restricted to materials only, as the exposition is designed for concentration on the basic constituents available to manufacturers for product design and manufacture.

The Conference and Exposition will be held at the International Amphitheater in Chicago May 17-20. Advance registration cards for the Exhibition and Conference are available from Clapp and Poliak, Inc., 341 Madison Ave., N. Y. 17, N. Y.

Plastic tail cone of Navy P2V Neptune is 17 ft long, has good strength characteristics and lowers part cost 80%.

Scope Widens for Plastic Aircraft Structures

Fuselage Sections, Wings, Made of Reinforced Plastics

The plastic airplane moved a few steps closer to reality last month.

In California, the Zenith Plastics Co. started turning out two 17-ft tail cones a day for the Navy's P2V Neptune long range patrol plane produced by Lockheed Aircraft Corp. In Ohio, reinforced plastic wings, molded by East Coast Aeronautics, Inc., successfully completed preliminary flight tests on an Air Force trainer at Wright Air Development Center.

In both cases polyester-glass cloth laminates are used with sandwich construction. The tail cone sandwich filling is polyester-glass honeycomb; the wing structure utilizes cellular cellulose acetate. Both structures are fabricated by low pressure vacuum bag molding.

The tail cone is made in six parts which are subassembled with riveted lapped joints into two sections for shipment. The two sections are bolted together by means of attachment rings formed by integral laminated angles. The cone is attached to the main fuselage by means of a bolting ring formed by aluminum angles riveted to the front edge of the cone.

Metal-sprayed molds are used in production to insure tolerances that will allow interchangeability of parts. Close tolerance thicknesses are held on curved parts by means of a thickness router—a portable machine developed by Zenith engineers. It has indices that can be set to follow the contour of any part on which it is mounted and it operates virtually unattended. Designed for machining reinforced plastics, the device can also be used on metals.

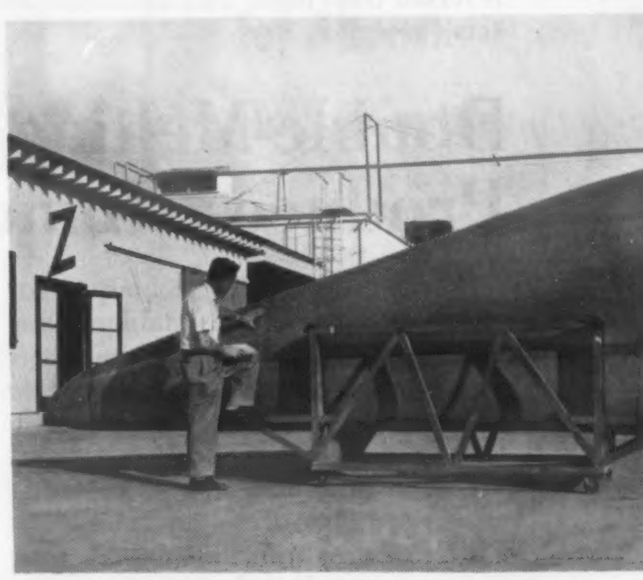
According to William Braham, Zenith's Chief Engineer, the plastic tail cone costs only about 20% of what a metal cone would cost. Breaking it down, he claims approximate savings of 80% in engineering manhours, 86% in factory floor space, 83% in production manpower and 73% in tool and equipment cost.

The plastic cone is reported to have withstood a test load up to 300% of the ultimate load, the maximum load that could be applied by the test rig used, without any sign of failure or local deformation.

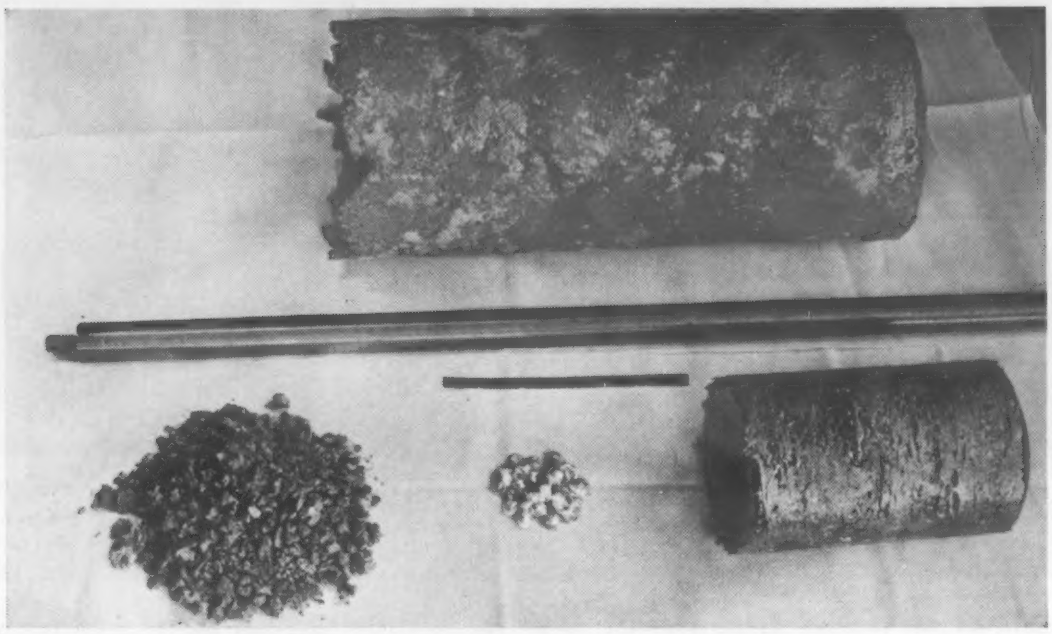
The plastic wings tested at WADC are the first to be test flown, according to the Air Force. Wing panels had been designed, constructed and ground-tested as early as 1944.

The outer faces of the wings vary

(Continued on page 222)



Large size and smooth contour of P2V tail cone is evident in picture above. Below: Tail cone is bolted to fuselage by aluminum angle riveted to base of cone.



Four stages in double melting technique for titanium alloy production are represented above. Piles of loose material represent sponge and alloying metal, ingot at lower right is first melt from non-consumable electrode furnace. Thin bar in center is forged from ingot, used as consumable electrode to make large homogeneous ingot at top of picture.

Double-Melting Titanium Produces Homogeneous Alloys

A double melting technique for producing homogenous titanium alloy ingots weighing up to 100 pounds is in operation at the Illinois Institute of Technology. The process can easily be applied to commercial scale production, according to foundation spokesmen, but the additional steps in the process are undoubtedly time consuming and costly.

The process begins by combining titanium and alloying metals, such as aluminum and silicon, in a non-consumable electrode arc melting furnace. This first melt produced an ingot containing the desired proportion of materials, but the alloying materials are likely to be segregated and the ingot is not homogenous enough to be of much use.

The additional steps in the process consist of forging the segregated ingot into a thin rod and remelting the rod as a consumable electrode. Fed vertically through the top of the furnace, the rod melts in the arc and forms a pool of molten metal. The consumable electrode arc maintains a larger pool of molten metal than is possible with the non-consumable type, and since all materials must pass through the arc, the final ingot has all alloying materials more evenly distributed, resulting in an homogenous alloy.

The consumable electrode furnace is of the continuous casting type, in which the ingot is withdrawn from the bottom as the melt accumulates. The crucible in which the final ingots form is a six inch cylinder of 1/4 in. copper enclosed in a brass water jacket. An argon atmosphere is maintained in the furnace to prevent oxidation of the titanium melt.

Ingots with a greater diameter than 6 inches can be made, provided power is increased. The only limits in ingot size are the physical distance the ingot can be withdrawn and the diameter of the molten pool that can be kept in the crucible.

More Volume for Vacuum Alloys

A jump in the demand for vacuum melted high temperature alloys has resulted in the first commercial production schedules for the special purpose materials.

Manufacturers of high quality ball bearings have used many tons of vacuum-refined low-alloy steel in the last six months. Reports indicate that the upswing in demand will continue. The vacuum-refined metal ha exceptional cleanliness and freedom from gas, which results in a higher manufacturing yield and better machining qualities. The commercial alloy, Ferrovac 52100, is produced by Vacuum Metals Corp., a subsidiary of the National Research Corp. Several sources have reported two and three fold increase in operating life of ball bearings made from vacuum refined alloy. Field tests of various bearings types are in progress; other vacuum melted alloy steels for applications requiring high fatigue strength are also under test.

During the past year vacuum melted alloys and high purity metals have been used increasingly in vacuum tube components. Again, the gas free quality of the material is useful in meeting the high-temperature, high-vacuum requirements of precision electronic applications. High purity nickel, copper, iron and dilute alloys of these metals are more in demand, and some alloys which hitherto have been produced only in experimental lots are being standardized for commercial production.

What They Said . . . . .

ALTERNATES "We wait too long if we delay until we are in total war before designing military equipment using substitute and alternate materials. Our long range security depends upon achieving equipment designs that can be produced in adequate quantity . . . to meet the threat of total war. The time to design such equipment is while we can spare technical personnel for the job and while we can convert to the use of such new equipment with least dislocation of industry and combat troops." *Hon. C. S. Thomas, Asst. Secretary of Defense for Supply and Logistics.*

SUBSTITUTES "An available material that is good enough is better than an ideal material that is insufficiently available." *Franklin P. Huddle, Chief, Materials Conservation Div., Office of Asst. Secretary of Defense.*

Materials BRIEFS

Kilned Steel Ceramic-type tunnel kilns have proved to be the most economical method for heating steel billets to temperatures required for center piercing in seamless tube fabrication. Compared to roll down furnace, process reduces BTU's 20%, diminishes scale loss, requires less labor.

Glass Screens Plastic coated glass fiber window screens are proving weather, wind and bug resistant in a series of tests now being conducted by the Air Force. Plastic screens are particularly promising for seacoast use, where some metal screens disintegrate within six months, leave disfiguring stains on building exteriors.

Heavy on Light Metal The Fabricast Division of General Motors used more than 20 million pounds of aluminum for castings last year.

Buckets and Blades Over 1000 blades must be precision machined to 1/10,000 inch tolerances in typical modern turbojet engines for military use.

Steel Gain The 6.8 million ton increase in national steel capacity which took place in 1953 was spread out over 14 states. Ohio, with a gain of 1,744,800 tons of capacity, led the field of states registering increases.

Small Amplifiers Low level magnetic amplifiers capable of reacting to signals as feeble as one billionth of a watt have been successfully fabricated using wire only one mil thick wound on a core of layers of 0.00012-inch steel foil. Amplifiers are capable of direct operation from the output of thermocouples and similar low energy devices.

Titanium Shrouds Substituting titanium for stainless steel in the after burner shrouds of the Chance Vought Cutlass jet fighter resulted in a saving of 20 lb per plane. Performance tests showed titanium sasisfactory in physical characteristics.

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ALFRED L. BOEGEHOLD

Men of Materials . . .

their views on development and utilization of engineering materials in industry

When asked about his work, Alfred L. Boegehold, Assistant to the General Manager of General Motors Research Laboratories, is likely to reply, "Back in 1920 I had an urge to develop something to be used on automobiles. And I still have it." The answer explains in part how Mr. Boegehold came to be with General Motors, where there are certainly enough automobiles to "use things on", and it also gives an indication of the careful focus on the objectives of research in a large manufacturing corporation—to find practical improvements in materials and design of specific products in terms of production cost and test of the market place.

In the course of becoming one of the top men in General Motors materials engineering, Mr. Boegehold has certainly succeeded in developing a number of things that have gone into the production of automobiles. He has also been instrumental in the development of new metallurgical concepts and techniques. Perhaps his most important work from the standpoint of materials selection and metallurgy in general was his part in the development of the Jominy hardenability test for steel. The work of Boegehold and Jominy led to the present widely used method for classifying steel which enables steel users to specify steels in terms of the depth of hardness required for specific applications.

Mr. Boegehold's work has not been limited to hardenability—his long list of publications includes selection and application of automotive steels, heat treating for machinability, conservation of strategic materials in automotive construction, copper-nickel-lead bearings, and production and utilization methods for automotive cast iron.

His achievements have been widely recognized by professional societies. In 1938 he delivered the Campbell Memorial Lecture to the American Society for Metals, was awarded the Whiting Prize by the American Foundrymen's association in 1929, and was recognized for his work in cast iron by the same society in 1942. The American Society for Metals named him President in 1947. He is currently active on the Nickel Conservation Panel of the Materials and Metals Advisory Board of the National Academy of Sciences and leads the Engineering Materials Activities Committee of the Society of Automotive Engineers.

In speaking of materials engineering, Mr. Boegehold tends to steer clear of generalizations, and considers short cut methods and oversimplifications as a snare and delusion. The only generality to which he will subscribe is, "Every single part of a manufactured product is a problem in its own right. And the problems surrounding each part are constantly in a state of flux in the light of changing prices, supplies of materials, and the infrequent development of new ideas or processes". To him, materials selection is basically a problem of "saving money while meeting rigid standards." In regard to the specification of metals for use in particular applications, he believes "there is no substitute for having a general metallurgist right on the premises. Our own engineers—and this is nothing against them— come to us for materials advice and get to know the field relatively well in regard to their own problems. But when they start specifying metals on their own, time after time we have had to go in later and clear up a costly error." While this may sound like an ultraconservative approach, the problems inherent in multimillion unit production schedules which add up to billions of dollars worth of materials and labor, do not allow a very wide margin for error.

In respect to research work, Mr. Boegehold thinks there has been a great deal of loose talk involving so called pure research and commercial research. He would rather use the terms "academic" and "industrial". Academic research, he believes, is characterized by providing "answers only" to arbitrarily posed problems that may have little or nothing to do with production or application. Industrial research, on the other hand, is research with a specific and limited objective. It is accountable to management for its costs, and any research department that cannot show the results of its work in terms of profit on the balance sheet is not justifiable. "That does not leave us time", he says, "to play with the toys of academic research, no matter how interesting they may be, unless it is clear that they will lead to the solution of some of our own specific problems. There are enough demands on us to perfect materials and processes which are on the threshold of profitable use."

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—One Point of View

What is Ferrous?

In this age of double talk on the political and diplomatic fronts, it becomes more important than ever that a more precise use of language be insisted upon in our technical and scientific literature. Lately our attention has been attracted several times to flagrant misuse of the word ferrous.

By definition, ferrous means: "Of or pertaining to iron; composed chiefly of iron or, as in the case of iron minerals, compounds of iron". By that definition, as well as by common usage, a ferrous metal or alloy is one containing more iron than it does any other element.

Just recently we saw listed as ferrous alloys, such materials as Monel and several other nickel-base alloys. True, all of them might contain some iron, but they are certainly not iron-base, hence ferrous alloys.

The same carelessness is now evident in terming certain metals steels. In one recent case, a new alloy which had at least 83 percent of other elements was called steel. In another, Stellite was grouped among stainless steels.

Possibly we need some new terms to describe our metal groups. For example, the term nonferrous often is not entirely accurate. One would expect from that designation that the metal or alloy contained no iron. The truth is that most commercial alloys contain some iron even if it only appears as an impurity that cannot be removed.

At the moment we can't shed too much light on the matter. We can only hope that the various committees on nomenclature in our technical and standards societies try to restore order to our maze of tangled names.

More Research

During the last few years we have heard many speakers tell of our need for further research—basically of a fundamental nature. We have echoed those needs on these pages. However, it would seem that this is a proper time to repeat our concern over research.

Studies have shown that throughout the world and throughout history, social well being and prosperity have gone hand in hand with research and with the new products which come through research. We have only to look back to ancient China where gunpowder was discovered. In that era, China was a leading civilization. Other examples could be cited over the centuries, but a more recent example is Germany during the period during the two World Wars. Many of the goods we enjoy today came about through German research in those years.

At the moment, the United States leads in many forms of research and at the same time leads in per capita income, general prosperity and world affairs. Research will have to continue if we are to maintain these leaderships. Here are some of the new materials we now enjoy which have come about through research: synthetic rubbers, plastics and synthetic fibers, rare earths, silicones, fiber glass and many others.

The aircraft industry is now at the point where existing materials will not do what must be done to permit projected performances. New and improved materials will have to be developed through research. This research should provide the materials we need, help us maintain world leadership and make provision for our future economic well being.

T. C. Du Mond

LOADING die with rhenium powder prior to pressing.

PRESSING rhenium powder into bars suitable for sintering.

Rhenium Metal—Its Properties and Future

by L. W. KATES, Atomic Energy Div., Sylvania Electric Products, Inc.

● MOST RECENT ADDITION to the group of ductile metals, rhenium is now being developed for use as a new refractory material. The metal which resembles manganese in chemical properties and tungsten, physically, has been neglected until recently because of fabrication difficulties.

Because of its extremely high melting point (5738 F), rhenium is difficult to prepare by melting, although small ingots have been made this way. There are two other methods that have been used in the past for preparing massive rhenium. One method is consolidation of rhenium powder by pressing, sintering, and subsequent hot and cold deformation. The other is by vapor deposition onto a hot wire by dissociation of the chloride. Much of the early work on the metal was done on wires prepared in this way, but the availability of good quality metal powder coupled with improvements in the powder metallurgy and metal working techniques has led to successful preparation of the massive metal by the press-and-sinter method.

Physical Properties

Some of the physical properties of rhenium are given in a table. Values for tungsten are given for comparison. The melting point of rhenium is exceeded only by that of tungsten among the metallic elements. Rhenium has a higher density than the more common refractory metals. Only platinum, iridium and osmium have higher densities. The electrical resistivity is about four times that of tungsten at room temperature and remains somewhat higher at elevated temperatures.

The boiling points of rhenium and tungsten are about the same. It has been stated that the vapor pressure of rhenium at temperatures around 4500 F is somewhat lower than that of tungsten. This factor is of particular significance in lamp and electronic applications. It is possible, however that these observations are not indicative of a lower vapor pressure for rhenium but, rather, that rhenium does not deteriorate as rapidly as tungsten in a slightly moist atmosphere at elevated temperature due to repeated oxidation and reduction. Present indications are that rhenium is very much less likely to be attacked by this "water cycle" treatment.

The crystal structure of rhenium

SINTERING AND ANNEALING rhenium compacts by passing a heavy current through the material.

DRAWING rhenium into wire can be done although the metal hardens rapidly upon working.

Just emerging from the laboratory, rhenium in ductile form is being investigated for electrical contacts, thermocouple alloys and pen points. . . . Other applications are sure to develop as its characteristics become better known.

is hexagonal close-packed, while those of tantalum, molybdenum and tungsten are all body-centered cubic. This suggests that rhenium would not be quite as readily deformed as the other materials. The coefficient of linear expansion is given as 6.9 x 10^{-6} per F along the hexagonal axis while the coefficient perpendicular to this axis is much lower, 2.6 x 10^{-6} per F. The average expansion in a randomly oriented, fine grained piece would then be somewhere between these two figures and could be expected to be somewhat higher than those for tungsten and molybdenum which are 2.4 x 10^{-6} per F and 2.7 x 10^{-6} per F respectively.

Mechanical Properties

Because of fabrication difficulties, it is a problem to obtain pieces large enough for testing and little information is available on the mechanical properties. Tensile strength of vapor-deposited material is about 70,000 psi with a ductility, as measured by the elongation, of 24%. Some data have been obtained for metal prepared by powder metallurgy techniques and these indicate that the tensile strength of annealed material is in excess of 120,000 psi while the ductility is about 25%. Some preliminary data on the modulus of elasticity indicates that it is high, in excess of that for tungsten, which is 50 x 10^6 psi.

Rhenium is somewhat more resistant to abrasion than tungsten. The hardness of annealed rhenium is 247 Vickers, while that of annealed tungsten is 392.

Corrosion Resistance

The effects of various atmospheres on the corrosion of rhenium are shown in a table. Massive rhenium is not attacked by atmospheric air at room temperature; rhenium powder, however, or porous compacts left exposed to air, form an oxide which hydrolyzes to perrhenic acid so that the oxide formed is not a protective one. Rhenium oxidizes in about the same manner as tungsten when heated to 1830 F in air. It begins to oxidize in air at a temperature as low as 750 F however.

Rhenium can be heated to any temperature in an atmosphere of wet or dry hydrogen without any attack. Hydrogen is a suitable atmosphere for high temperature sintering of powdered compacts. Rhenium is un-

affected by dry, pure inert gas atmospheres. The halogen gases, however, attack it.

The metal is resistant for long periods of time to attack by hydrochloric acid but is attacked by nitric acid and hot sulfuric acid.

Fabrication

Rhenium has not been fabricated into massive metal forms such as wire, rod and strip, until very recently because several of its properties make it difficult to work. Although small buttons have been arc melted, rhenium has the same limitations for melting as tungsten and tantalum. Molybdenum on the other hand, with a melting point several hundred degrees lower, is now melted and cast commercially.

The use of powder metallurgy methods, pressing, resistance sintering by passing a heavy current through a bar of the pressed powder, followed by mechanical working, would appear to be a straightforward way to prepare the material. Up to a certain point, this is true. Rhenium can be sintered to densities in excess of 90% of theoretical and it does not have the brittleness after sintering that is found in tungsten.

In the mechanical working steps, however, the greatest difficulties occur. Ingot after ingot of the material has been sintered to high density, has exhibited excellent room temperature and elevated temperature ductility in the early deformation steps, but has failed in the later stages of working. This is due to an extremely rapid rate of deformation-hardening, probably higher than that for any other metal known. This means that relatively light reductions in cross-section must be made between anneals, otherwise the material will become overworked and crack. To complicate matters further, if only light passes are taken, the annealing temperature to obtain complete softening is in the vicinity of 2700 to 3600 F. As an example, the hardness of annealed rhenium is about doubled, as a result of a 10% reduction in area. A comparable reduction in area for tungsten causes about 8% increase in hardness. This problem can be minimized by careful working at the proper temperature. It is actually a desirable property for wire drawing because the wire, after passing through the die, has been so strengthened, even though the cross-section is decreased, that there is no tendency for the wire to break under the pull necesssary to draw it through the die.

An indication that rhenium has low notch sensitivity was obtained during wire drawing. Transverse cracks formed when a piece of wire was overworked as it was pulled through the die but, in spite of a reduction in cross section of about 20 to 25% resulting from the cracks, no failure occurred.

In spite of the problem introduced by rapid deformation-hardening, rhenium can be readily formed. It is very ductile in the annealed state and, so long as it is shaped with a minimum of cold work in any particular area, no difficulty is introduced. It can be bent, coiled, rolled, swaged, and drawn at room temperature if proper precautions are observed.

Applications

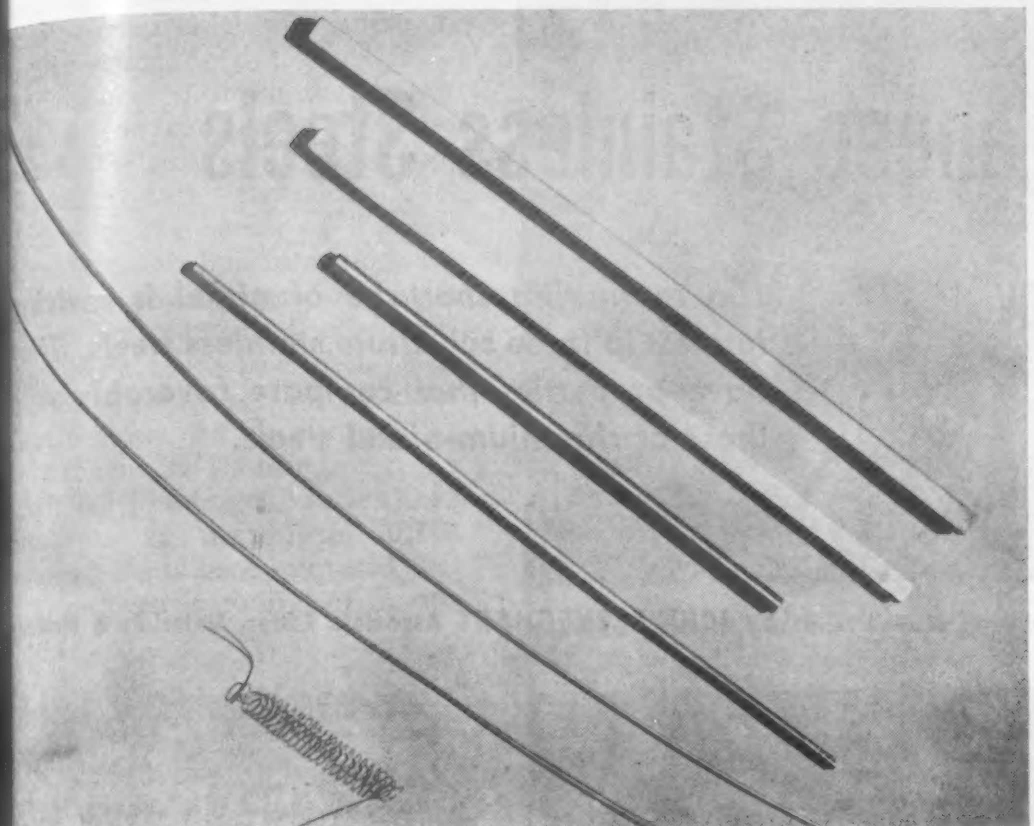
At present, practically all the rhenium produced in the free world is being used in research and development projects. There has been in the past a limited production, in the order of several hundred pounds per year in Germany, but the plant producing the metal is now within the Soviet-controlled zone and no information is available on present production.

Comparative Physical Properties of Rhenium and Tungsten

	Rhenium	Tungsten
Density, Lb/Cu In.	0.75	0.70
Melting Point, F	5738	6116
Coef of Exp per ° F	$2.6\text{–}6.9 \times 10^{-6}$	2.4×10^{-6}
Elect Res, Microhm-Cm		
Room Temp	21.1	5.3
4500 F	131.1	82.2
Boiling Point, F	10,650	10,700
Crystal Structure	Hex. close packed	Body-centered cubic

Corrosion Resistance of Rhenium

Corroding Medium	Effect
Air	
Dry air at room temp	No attack
Moist air at room temp	Some attack
Dry air at 1830 F	Extensive oxidation
Gases	
Wet or dry hydrogen	No attack
Dry inert gases	No attack
Chlorine	Attacked
Bromine	Attacked
Fluorine	Attacked
Acids	
Hydrochloric acid	No attack
Nitric Acid	Extensive oxidation
Cold sulfuric acid	Slight attack
Hot sulfuric acid	Some attack



henium can be bent, coiled, rolled, swaged and drawn at room temperature if proper recautions are observed.

Many possible uses have been sug-ested but most have not been in-estigated because of the unavailabil-y of massive metal. Applications hich do not require metal in this orm such as catalysts, electrical con-ct alloys, thermocouple alloys and ear resistant alloys, have received he most attention. Colloidal rhen-m has been prepared for use as a atalyst and shows some promise in ertain organic reactions. Alloys con-aining less than 10% rhenium have een investigated for electrical make-nd-break contacts and have shown ery good resistance to transference of he metal during operation. Thermo-ouple alloys of the platinum-rhod-m type with rhenium substituted or all or part of the rhodium are in-resting because of the high emf hat they generate compared to the onventional platinum vs. platinum-hodium couple. At 2200 F, for ample, a Pt/Pt=8% rhodium al-y gives an emf of about 12 milli-olts while a Pt/Pt-8% rhenium alloy ives about 30 millivolts. Alloys pre-ared by powder metallurgy methods omposed of 50 to 99% rhenium ith tungsten, nickel, molybdenum, nd others, have been used success-lly for pen points and have shown xcellent wear resistance.

Rhenium appears to have consider-ble potential as a material for elec-ronic applications. Its high melting oint, ductility after high tempera-re treatment, and high electrical resistivity make it a particularly promising material for such applications as cathode and filamentary emitters and heater wire for indirectly heated cathodes in electronic tubes. The high electrical resistivity at elevated temperature, compared to tungsten, permits an increase in the permissible wire diameters used, thus leading to more rugged filaments or heaters.

Rhenium appears promising for incandescent lamp filaments. It is affected only slightly by the "water cycle" which means that bulbs with rhenium filaments would not tend to blacken nearly as much as tungsten filament lamps. Also, tungsten may become brittle after prolonged heating at very high temperatures, while rhenium remains quite ductile. The higher resistivity of rhenium may also be useful in this application permitting somewhat heavier filaments to be used for a given power input.

There are probably other uses for rhenium which have not yet been considered. The fact that it apparently does not form carbides, for example, suggests the possibility that rhenium probes or even constructional parts can be placed in contact with carbon or graphite at very high temperatures without embrittlement. In this same connection, the high melting point of the metal is an indication that the high temperature creep and rupture strength is probably good so that it may be usable as a structural material at elevated temperature in non-oxidizing atmospheres. Finally, the field of ductile high-rhenium alloys has not been extensively investigated.

Occurrence and Separation of the Metal

Rhenium has been found in widely scattered locations all over the world, including Scandinavia, Germany, Africa, Japan, Australia, Siberia, and the United States, but it is still a realatively rare metal, being about 1/1000 as abundant as molybdenum. Rhenium does not occur as a massive mineral but is often found as a minor constituent in molybdenite, a molybdenum sulfide ore. Most of the rhenium presently obtainable in this country is derived from flue dust from molybdenite-bearing copper ores.

The method of recovering rhenium from flue dust is described in the patent of Melaven and Bacon. Briefly, this method includes treating the dust with water, which dissolves out the soluble rhenium oxide and filtering off the residue. The rhenium-rich filtrate is mixed with potassium chloride, and potassium perrhenate precipitates out. This material is recovered by filtration and decantation and subsequently purified by fractional crystallization. Potassium perrhenate is converted to metal by hydrogen reduction. The other reaction product, however, is potassium hydroxide and this must be removed by leaching. The highest quality metal powder is made at the present time by reoxidizing the material obtained by hydrogen reduction of the potassium salt, dissolving the oxide in water, then precipitating out ammonium perrhenate by passing ammonia gas through the solution. This is again reduced in hydrogen to produce the metal powder, which is the present commercially available form of the metal.

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Chromium-Manganese Stainless Steels

Where They Stand To-day

The continuing shortage of nickel is reviving interest in these substitute stainless steels. They have properties that compare favorably with those of chromium-nickel steels.

by JOHN L. EVERHART Associate Editor, Materials & Methods

● BECAUSE OF THE strict control exercised over nickel during the past few years and the probability of similar control in future emergency periods, there has been a revival of interest in other elements which can be used to form austenitic steels. As a result, at least one steel is in commercial production in which manganese has replaced most of the nickel.

The replacement of nickel by manganese in stainless steels was investigated many years ago by the Union Carbide and Carbon Corp. and several chromium-manganese steels were in commercial production in the late 1930's and early 1940's. In Europe, both the Germans and Russians have had steels in commercial usage for a number of years in which manganese replaces all or part of the nickel. One of the German steels is quite close to the American steel in composition.

Among elements which promote the retention of austenite at room temperature are carbon, nitrogen, manganese and copper in addition to nickel. These elements are more plentiful than nickel and it is possible to replace most of the nickel by using them.

A study of the chromium-manganese system showed that to produce a fully austenitic structure from chromium and manganese alone, the chromium content cannot exceed 13% and at this chromium level more than 13% manganese is required. Lower manganese content or higher chromium produces a mixed structure of martensite and austenite. Further investigation showed that alloys containing 16 to 18% chromium and 6 to 14% manganese can be made fully austenitic by the addition of 0.1 to 0.15% nitrogen and adding nickel in the range 2 to 6%.

The addition of nickel to chromium-manganese 18:8 increases the ductility. The effect is apparent with 1 to 2% nickel but is still more noticeable with 3 to 6%. In low carbon steels of this type, the manganese can be reduced below 8%. Fully annealed steels containing 6% manganese and 5% nickel are comparable in ductility to 18:8 chromium-nickel steels. The quantity of nickel necessary to form austenite in these chromium-manganese steels varies with the manganese content and numerous equivalent combina-

Effect of Cold Working (Houdremont)

Nominal Composition—%	Ten Str Psi Annealed	Ten Str Psi Cold Rolled 40%
18 Chromium—8 Nickel	93,000	168,000
18 Chromium—8 Manganese	113,000	182,000
15 Chromium—8 Manganese	120,000	228,000
15 Chromium—12 Manganese	121,000	200,000

Effect of Temperature on Properties (Houdremont)

Nominal Composition %	Temp, F	Ten Str, Psi	Yld Str, Psi	Elong (L=5 dia) %	Red of Area %	Impact Str Mkg/Cm^2
0.1 C	−330	228,000	72,000	31	52	—
9 Ni	Room	90,000	31,000	60	75	24
18 Cr	930	67,000	14,000	44	40	24
	1650	13,000	11,000	20	—	23
0.1 C	−330	188,000	57,000	9	2	10
8 Mn	Room	142,000	31,000	33	55	26
1.5 Ni	930	60,000	13,000	48	69	23
14 Cr	1650	13,000	10,000	68	73	20
0.08 N						
0.1 C	−330	157,000	87,000	18	18	20
14 Mn	Room	100,000	38,000	69	73	31
15 Cr	930	60,000	14,000	50	70	30
1.5 Ni	1650	23,000	13,000	49	60	23
0.1 N						

ions are possible. Nickel is about wice as effective as manganese in orming austenite.

Addition of nitrogen to the low ickel or low manganese alloy also ncreases the stability of the austente. Thus 18:8 chromium-nickel which is on the border of the ausenite-martensite transformation can e stabilized by nitrogen. Although ey are not commercial, other ausenitic steels which have been stabilized by nitrogen are 1) 23 chromium, 5 nickel, 0.25% nitrogen, 2) 0-22 chromium, 3.5 manganese, 3.5 ickel, 0.2% nitrogen, and 3) 15 hromium, 15 manganese, 0.2% itrogen. It has been estimated that 2% nitrogen is equivalent to 4% ickel.

6-16-1 Chromium-Manganese-Nickel

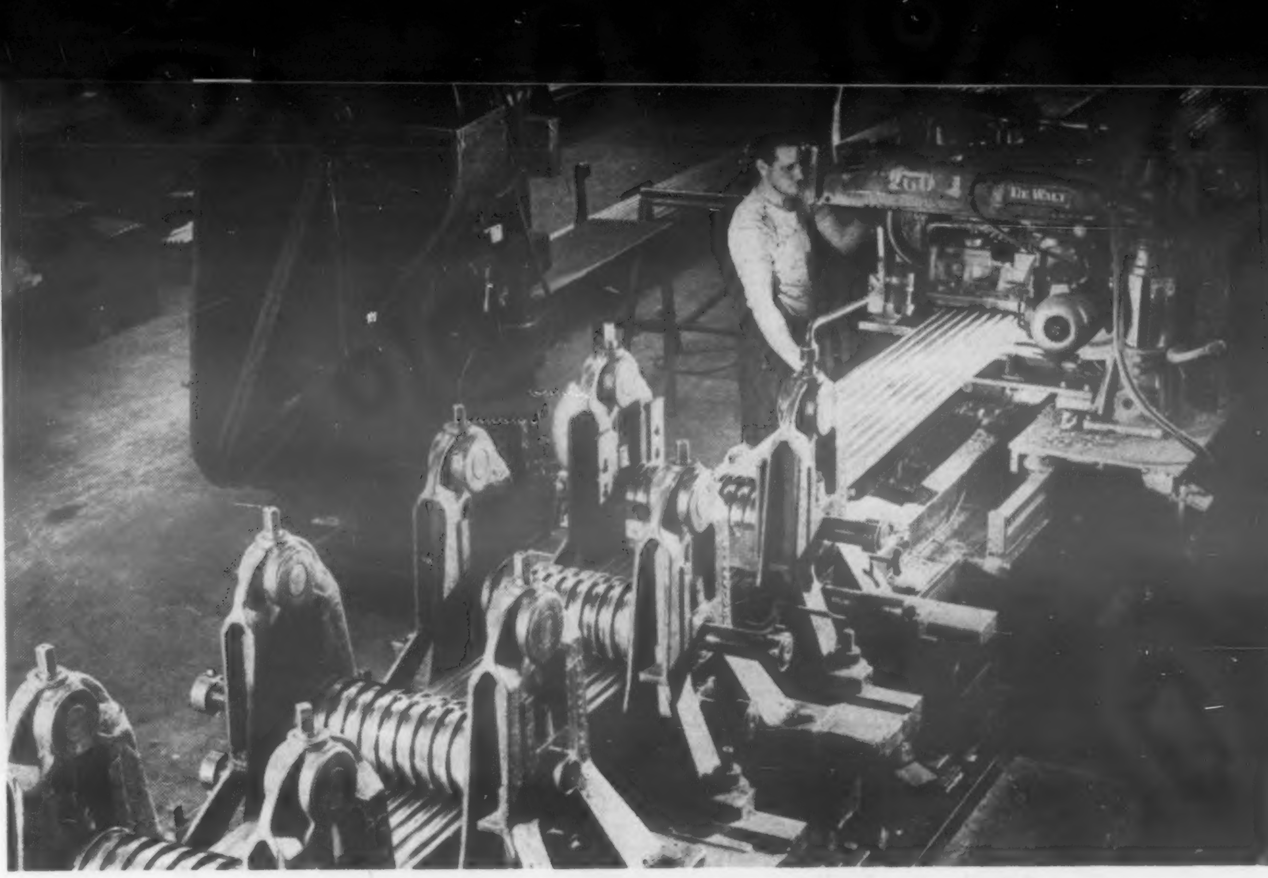
This grade, the only chromium-manganese steel in commercial production at present, has a nominal composition of 15 chromium, 16.5 manganese, 1 nickel, 0.15 nitrogen and 0.10% carbon. This steel is called TRC by the Budd Co. which has used it in the construction of railroad cars and trailer truck bodies.

TRC has a higher work-hardening rate than 18:8 chromium-nickel steel but about equal to 17-7 steel and can be fabricated with the procedures used in forming type 301 or 302 stainless steel. In resistance to milder atmospheric corrosion, TRC appears to be equivalent to 18:8 also. On the basis of the production of parts from several thousand tons of the new alloy, Budd considers that TRC and type 302 are interchangeable.

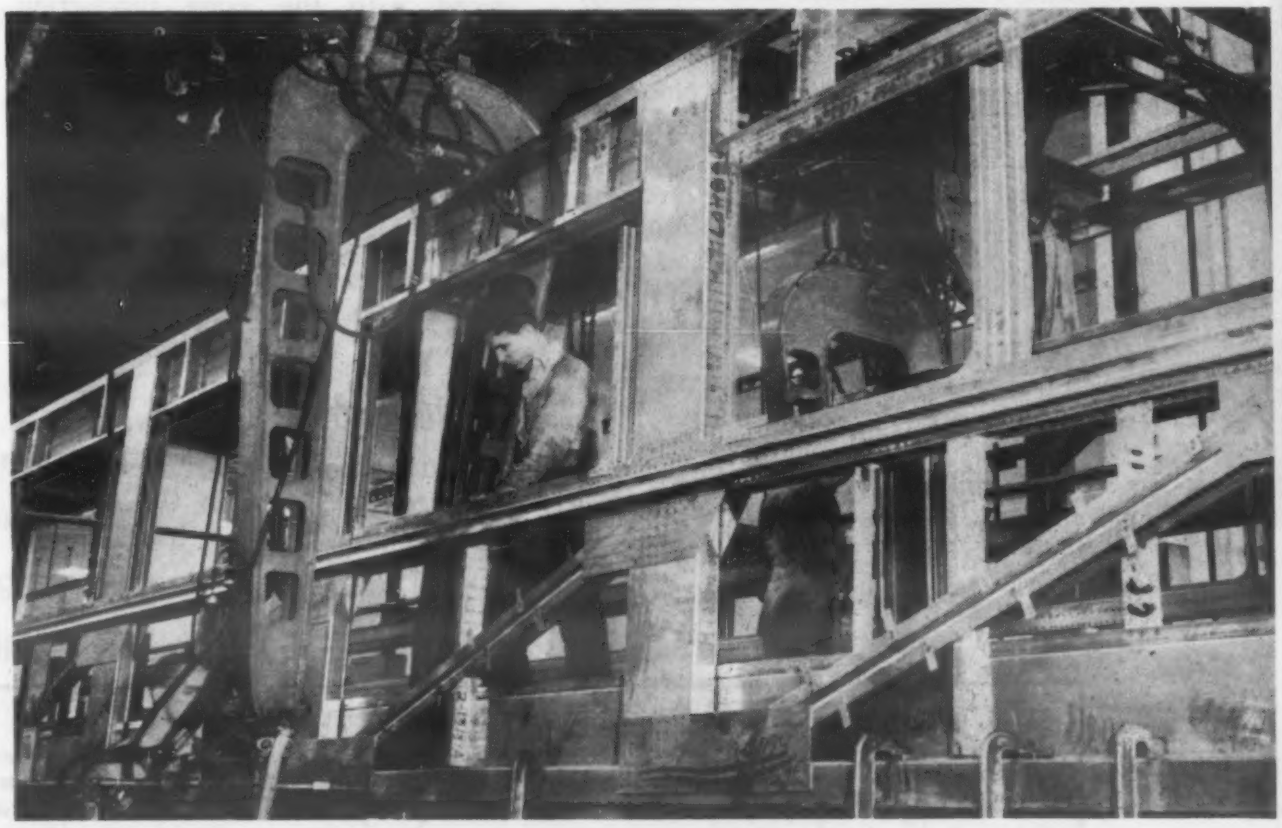
In the opinion of Allegheny Ludlum the 16-16-1 alloy does not completely match 18:8 in applications of a highly corrosive nature. It is considered useful however for less critical applications.

17-6-4 Chromium-Manganese-Nickel

This steel was developed about 10 years ago and was in limited commercial production until the restrictions placed on nickel content several years ago caused it to be scontinued. The composition was .7 chromium, 6 manganese, 4 nickel, 0.15 nitrogen and 0.10% carbon. The mechanical properties and corrosion resistance of this steel were quite close to those of 17-7. Work-



FORMING corrugated sections of new chromium-manganese steel for the roof of a light weight car.



JOINING side-sections of cars is readily performed by shot-welding.

FABRICATING the roof sections of a vista-dome car.

ing characteristics of the two materials were similar also, thus it was possible to replace 3% nickel with 4½% of manganese and produce an alloy of similar characteristics.

Two standard Russian steels are quite close to this steel in composition. However, both have considerably higher carbon contents and one contains 1% tungsten while the other contains 2% silicon. This tendency to use high carbon stainless steels appears to be rather general in Russian steelmaking practice.

18-10-4 Chromium-Manganese-Nickel

Allegheny Ludlum Steel Corp. carried its development of 17-6-4 and 16-16-1 further and has an extensive customer evaluation program under way on an additional alloy of this type with properties closer to 18:8. This alloy containing 18 chromium, 10 manganese and 4% nickel is similar to 18:8 in mechanical properties and also in resistance to corrosion as determined by laboratory tests in boiling nitric acid, salt-spray and copper sulfate-sulfuric acid.

16-15-6-6 Chromium-Nickel-Manganese-Molybdenum

One of the most widely used alloys for gas turbine wheels is the composition known as 16-25-6. This alloy contains balanced quantities of chromium (16%), nickel (25%), and molybdenum (6%). It was developed to obtain a material free from such highly strategic metals as cobalt, columbium and tungsten, and it fulfilled that objective admirably but still required 25% of nickel which is likely also to be in short supply in an emergency. Therefore modifications designed to conserve nickel were investigated.

This work showed that 6% manganese could replace 10% of nickel if the carbon content was limited to a maximum of 0.08%. The new alloy 16-15-6-6 was the result.

The modified alloy can be produced with the same production schedule as the original. Testing of the materials showed that the room temperature properties of the two are similar. At elevated temperatures, preliminary work has shown that the properties of the modified alloy in the solution quenched condition are similar to those of the original alloy up to 1400 F but may be inferior to 16-25-6 at higher temperatures.

Welding Rods

Two chromium-manganese stainless steels are used in Germany as welding rods. Their compositions are 19 chromium, 5.8 manganese, 8.0 nickel, 1.3 silicon, 0.6 titanium and 0.45% carbon; 10 chromium, 18 manganese, 0.4 titanium, 0.8 silicon and less than 0.12% carbon. These steels are used for high grade welds in carbon and alloy steels of all kinds and for the welding of heat resisting chromium manganese steels.

Acknowledgment

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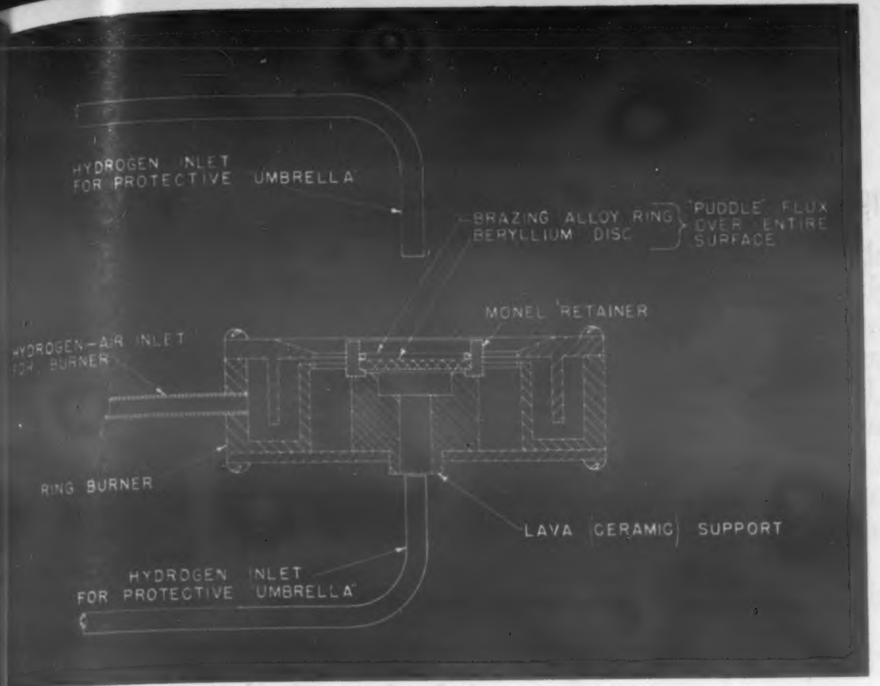
Properties of Some Chromium-Manganese Stainless Steels

Nominal Composition—%										
C	Cr	Mn	Ni	Other	Condition	Yield Str, Psi	Ten Str, Psi	Elong % 2 In.	Hardness	Reference
American Steels										
0.1	16/20	8/10	—	—	W.Q. 1920 F	48,000	121,000	27	163²	Kinzel and Franks
0.1	15	16.5	1.0	0.15 N	H.R., Ann.	40,000	100,000	60	R_B 84³	Budd Co.
0.1	17	6	4	—	Ann.	43,000	125,000	70	R_B 86³	Lincoln and Mather
0.15	12	16	0.25	—	A.C. 1875 F	30,000	142,000	67	R_B 82³	Franks, Binder and Brown
0.8	15/17.5	6.5/8.5	14/17	5.5/7 Mo, 0.1/0.2 N	W.Q. 1900 F	58,000	110,000	45	195²	Ellis and Fleischmann
German Steels										
0.1	9	18	—	3 Si, 0.4 Ti	W.Q. 1925 F	—	110,000	40¹	—	Bandel and Wiester
0.1	12	18	—	0.5 Si, 0.7 V, 0.2 N	O.Q. 2100 F, A.C. 1375 F	—	125,000	20¹	—	Bandel and Wiester
0.1	14	8	1.5	0.08 N	—	31,000	142,000	33¹	—	Houdremont
0.1	15	14	1.5	0.1 N	—	38,000	100,000	69¹	—	Houdremont
0.21	19	8	1.0	—	A.C. 1560 F	69,000	129,000	25¹	—	Schmidt and Legat
0.16	17	16	1.3	—	A.C. 1560 F	62,000	100,000	34¹	—	Schmidt and Legat
Russian Standard Steels										
0.15/0.30	12/14	8/10	3.7/5.0	—	W.Q. 1920 F	—	118,000	36	—	Zapffe
0.35/0.45	17/20	4/6	3/7	0.8/1.0 W	—	—	—	—	—	Zapffe
0.35/0.45	17/20	3/5	5/7	1.4/2.2 Si	—	—	—	—	—	Zapffe
0.38/0.47	14/16	6/8	5/7	0.4/0.8 Mo, 1.4/1.8 V	—	—	—	—	—	

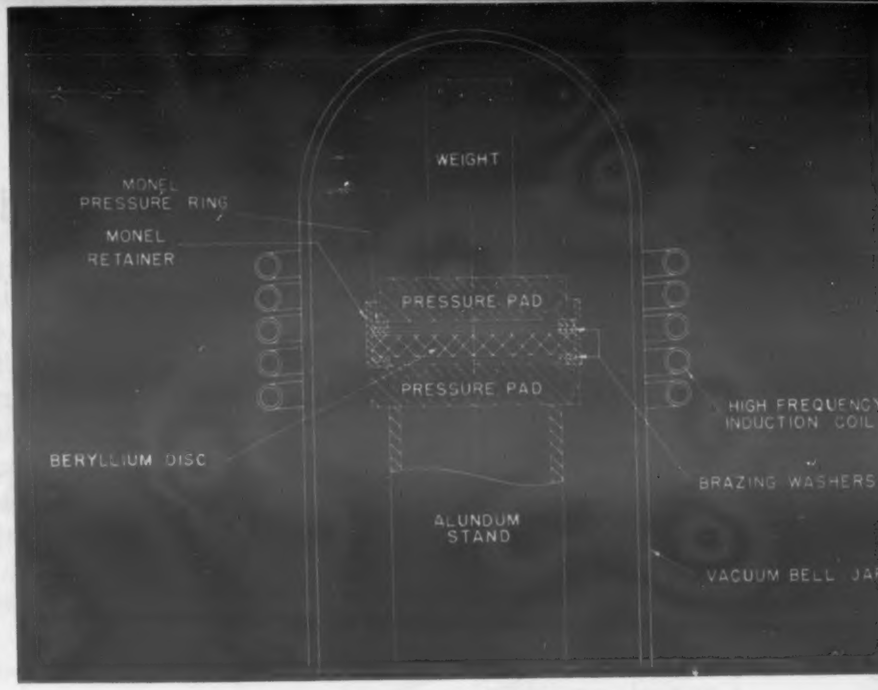
NOTES:
¹ *l = 5 d.*
² *Brinell.*
³ *Rockwell.*

W.Q.—Water Quenched.
H.R.—Hot Rolled.
A.C.—Air Cooled.
O.Q.—Oil Quenched.

Picture Credits: The Budd Company



Apparatus for flux brazing of beryllium.



Apparatus for vacuum brazing of beryllium.

by M. J. ZUNICK and J. E. ILLINGWORTH, X-Ray Dept., General Electric Co.

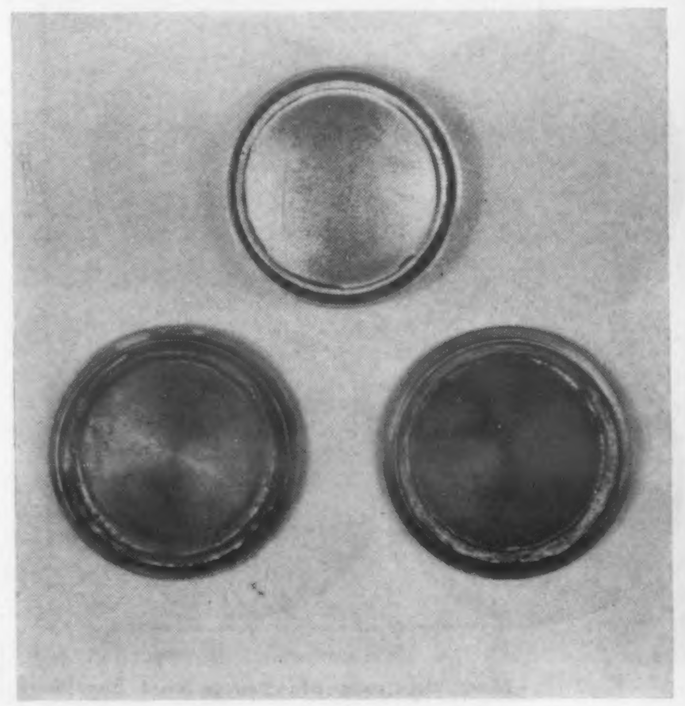
How To Braze Beryllium

Here are some techniques that have proved successful in overcoming the oxidation problem and insuring sound joints with this increasingly important metal.

• THE PROBLEMS ASSOCIATED with the brazing of beryllium are in some respects similar to those encountered in the brazing of aluminum and magnesium. Because of the higher brazing temperatures used, however, considerable more difficulty is encountered with beryllium. At high temperatures beryllium is quite active, with a great affinity for oxygen; unless it is properly protected during brazing, it will oxidize to a considerable depth and prevent a good brazing job.

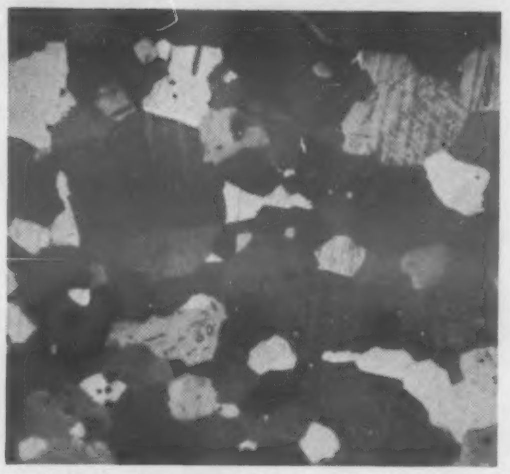
(The oxide film on beryllium does not have the same protective quality generally associated with the oxide film on aluminum. Beryllium is more like magnesium in this respect, as might be expected, since the two metals are in the same group on the periodic chart.)

The patent literature (*3, 4*) discloses numerous methods for brazing beryllium. Brazing materials recommended include copper, silver or a combination of copper and silver, each with or without additions of nickel, gold, beryllium, calcium, lithium, silicon, etc. Beryllium can be brazed to steel or various nickel-iron alloys, but monel is preferred. Beryllium disks can also be bonded to copper at high temperature and pressure by means of a powder mixture of beryllium and copper (*5*). Fluxing agents suggested are the halide salts of sodium, potassium, lithium, beryllium, magnesium and barium, alone or in combinations. Brazing is done preferably in a hydrogen or neutral atmosphere, or it may be done in a vacuum. Heating of the assembly can be accomplished by resistance or by high frequency induction. Mechanical pressure is optional.

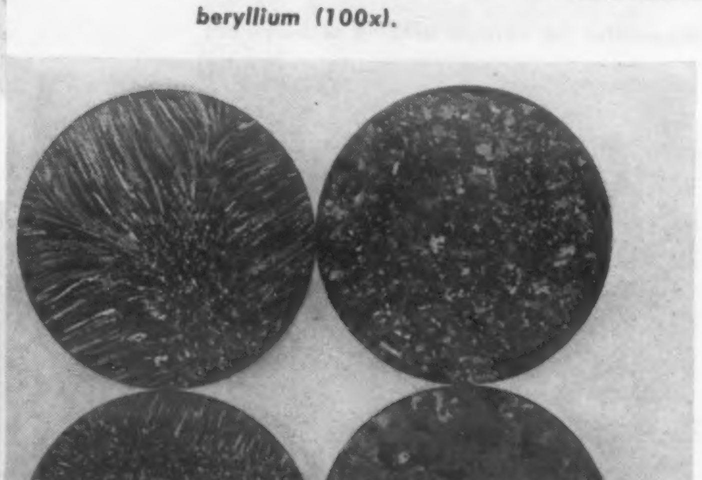


Some x-ray tube beryllium window assemblies. One at top was subjected to chemical polishing treatment described in this article.

Various types of pure beryllium metal are obtainable. In the past the x-ray industry had found it advantageous to use vacuum-cast beryllium rather than air-cast because of its greater density and higher purity, but considerable trouble was experienced in brazing the vacuum-cast metal because of its coarse and nonuniform grain structure. The metal had a tendency to crack along the grain boundaries, causing vacuum leaks; and the brazing material penetrated these fine cracks, to some extent, resulting in excessive filtration of the x-ray beams. (Better grain structures could probably be obtained with close control over cooling of the molten beryllium.) In recent years disks cut from hot pressed blocks have been available. This form of the metal, in addition to greater physical strength, offers the advan-



Typical microstructure of hot pressed beryllium (100x).



Macrostructures of vacuum cast beryllium.

tages of a small, uniform and dense grain structure. More recently, forged beryllium, both rolled and extruded, has become available. This form is considerably stronger than the others, but since its surface is often badly oxidized, brazing of forged beryllium is presenting some difficulties.

Flux Brazing

Where physical strength and not vacuum tightness is the main prerequisite, flux brazing may be considered. Flux brazing is also suitable for joining large pieces since no special equipment is required. Chief objection to flux brazing of beryllium is the subsequent corrosion resulting from entrapment of minute quantities of flux in voids and cracks in the joint, especially in the presence of moisture.

No special preparation of the beryllium is necessary prior to flux brazing except where the surface is badly oxidized. The following chemical polishing procedure (6) is highly recommended for removing badly oxidized surfaces:

1. Add 53¼ g. of chromic anhydride to 450 ml of 85% ortho-phosphoric acid and heat to about 300 F to dissolve the salt. Cool solution to 230 F and add 26½ ml of concentrated sulfuric acid.
2. Clean grease from the metal surface.
3. Immerse the metal sample in the solution at 230 F for about 2 min. (About ½ mil of surface is removed per minute of immersion time.)
4. Wash the metal quickly and examine it. If it is not polished satisfactorily, dry the metal carefully and repeat the procedure.

An electrolytic-chemical treatment (7) can also be used for removing oxidized surfaces.

A brazing alloy consisting of 50% copper and 50% silver is used for flux brazing. A special flux consisting of 60% (by volume) lithium fluoride and 40% lithium chloride is used. If large pieces are to be brazed and excessive heating is necessary, increasing amounts of lithium fluoride are added to the flux mixture or directly to the working area. Since lithium halides are extremely hygroscopic, special precautions are needed to keep the flux dry.

The parts or areas to be brazed must be kept flushed with pure hydrogen during the entire operation. Heating can be accomplished by a "ring-burner", by a hand torch using oxygen-hydrogen or air-hydrogen, or by high frequency induction heating. In all cases speed is essential to prevent excessive oxidation. Flux must be applied in excess before the heating is begun, and must be added as needed to keep the brazing material and joint area well fluxed during the entire heating cycle. The brazing metal may be preplaced or fed into the joint by hand.

If all conditions are satisfactory, the metal will melt and flow freely, forming smooth, massive fillets. However, holding the molten brazing material in contact with the beryllium for too long a period of time or raising the temperature too high will give rise to "run-away" alloying resulting in spongy, porous metal around the joint. Flux residues must be removed completely; otherwise excessive corrosion of the beryllium will occur shortly. Flux removal can be accomplished by mechanical means, followed by immersion of the surface in boiling water. Extended immersion in boiling water must be avoided because of its corrosive effect on the beryllium itself.

Where Beryllium Is Used

Since 1940, pure beryllium metal has been used as a window or port in many x-ray tubes. Because of its low atomic number and low density, it is highly pervious even to long wave-length x-rays. Its melting point (2325 F) allows the use of the high temperature solders that are needed in the joining of x-ray tube assemblies. In contrast to these advantages, the reactive nature of beryllium and its apparent lack of ductility must be considered. However, recent improvements in the metallurgy and processing of beryllium (1,2) seem to indicate that these drawbacks will be substantially mitigated in the near future.

Although the x-ray industry consumes only small quantities of beryllium, the metal is now being used in considerable quantities in atomic energy installations. Broader use of the metal has resulted in increased interest in materials and techniques suitable for high-temperature brazing of beryllium. The authors' experience in this field has been restricted primarily to the brazing of flat disks up to 2 in. in diameter and 0.030 in. or more in thickness. Techniques have arisen, however, that may prove useful to others concerned with beryllium joining.

Vacuum Brazing

Beryllium is brazed most successfully in a vacuum and by means of high frequency induction current heating. Pressures on the order of one micron (0.001 mm of mercury) are required to minimize oxidation.

For vacuum brazing, it is suggested that beryllium be electroplated with silver and/or copper. Only the areas to be wetted and joined with brazing metal should be plated. The brazing metal seldom flows beyond the plated areas; hence this method not only prevents excessive oxidation of the beryllium surface, but also practically eliminates undesirable flow of brazing alloy over the remaining surfaces. This is particularly important where the assembly is used for transmission of radiation because the heavy metals used in the brazing alloys, even in small quantities, would reduce transmission substantially.

The beryllium, particularly if badly oxidized, can be cleaned in the chemical polishing solution described above, or it can be cleaned by vigorous rubbing with moist sodium bicarbonate powder on a clean cloth. Following is a complete procedure for cleaning and electroplating beryllium prior to brazing:

1. Dip in 5% hydrochloric acid solution for 5 sec.
2. Rinse in warm water.
3. Dip in 5% sulfuric acid solution for 5 sec.
4. Rinse in warm water.
5. Electroclean (anodic) for 10 min at 195 F and 30 amp per sq ft in a solution containing 5 oz. per gal sodium hydroxide, 3 oz. per gal sodium carbonate and 5 oz per gal sodium cyanide.
6. Rinse in warm water.
7. Repeat steps 1, 2, 3 and 4.
8. Copper flash at 160 F and 50 amp per sq ft in a solution containing 3.5 oz per gal copper cyanide, 4.6 oz per gal sodium cyanide, 4.0 oz per gal Rochelle salt and 4.0 oz per gal sodium carbonate.
9. Rinse well in running water.
10. Electroplate at 75 F and 15-30 amp per sq ft to a minimum thickness of 0.0015 in. in a solution containing 6.0 oz per gal potassium carbonate, 5.5 oz per gal potassium cyanide and 4.0 oz per gal silver cyanide.

Alternatively, the beryllium can be electroplated to the same thickness in any standard copper plating solution. Other methods of plating on beryllium, reported in the literature (*8, 9*), could undoubtedly be used.

Since not the entire beryllium piece is to be plated, a suitable means for blocking-off is required. A number of organic stop-off agents are satisfactory for this purpose; in the case of round disks, however, it is convenient to stack them with alternate smaller diameter metal disks, clamp the stack with an ordinary C-clamp and plate the entire assembly. The plated beryllium disk is assembled in a monel retainer and heated to 1920 F, (when pure silver is used as the brazing material) by means of high frequency induction current.

Good vacuum brazed joints have been made without electroplating the beryllium. This has been accomplished with hot-pressed QMV beryllium in vacuums considerably better than one micron and only with systems of extremely high pumping capacity. Here the use of thin (0.0005-0.001 in.) zirconium or titanium washers between the beryllium and the brazing metal washers helps break down the surface oxide and promotes wetting. Use of these highly active metals is not particularly recommended, however, since localized erosive action sometimes occurs. Possibly the incorporation of 5-15% of these metals in the brazing material itself, where it would be more uniformly distributed upon melting, would improve the brazing process considerably.

Beryllium may also be brazed in electric furnaces operating with a pure hydrogen atmosphere provided all conditions are carefully controlled. We have found this method of brazing successful with use of BT silver solder. Extreme care must be exercised in preparing the beryllium prior to brazing in the hydrogen furnace, and the areas to be brazed preferably are electroplated with silver and/or copper as described previously.

The accompanying photograph shows three x-ray tube beryllium window assemblies that are brazed into monel retainers with pure silver brazing material. Note the high reflectivity of the assembly at the top. This assembly was cleaned in the chemical polishing solution previously described and was brazed in a vacuum. The other two assemblies were brazed in a vacuum but were not cleaned in the chemical polishing solution. The discoloration is probably due to an inherent oxide coating which was not removed prior to brazing. All assemblies shown were vacuum tight and suitable for use in x-ray tubes.

A Warning

The possible toxicity of beryllium and some of its compounds is a problem which the user should investigate thoroughly before any attempt is made to braze beryllium at high temperatures. This possible toxicity is rather peculiar in that it appears to be highly specific, varying greatly with individuals and conditions of exposure. Its effects frequently may not become apparent until several years after exposure. Considerable work has been done on safe methods of handling of beryllium and its compounds, particularly by AEC contractors (*10*). The effects of exposure to beryllium and its compounds, and their treatment, have been given considerable attention by the medical profession in the past few years (*11, 12*). The authors are not in a position to recommend proper methods of handling beryllium, as each case should be investigated specifically and recommendations obtained from reliable and authorized sources.

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Can Titanium Be Used in Bolting Applications?

Tensile, torque and stress-rupture tests on titanium bolts using silver or rhodium plated lock nuts give the answer.

by R. A. BAUGHMAN, Aircraft Gas Turbine Div., General Electric Co.

● THE USE OF titanium in many bolting applications is desirable from a weight saving standpoint. However, reports of its high degree of relaxation and ease of seizure and galling in contact with other materials have been considered too disadvantageous to warrant such applications. To check the validity of these reports, tensile, torque and stress rupture tests were run on RC 130B Titanium bolts, and results showed that titanium was satisfactory for bolting applications.

For the tests, RC 130B bolts, 7/16 in. in dia and having 20 threads per in. were obtained with ground and rolled threads. Some bolts were hot roll threaded, annealed and sand blasted, while others were cold threaded with immediate subsequent stress relief anneal. Austenitic stainless steel locknuts, both silver plated and rhodium plated, were used in conjunction with these tests.

Strength Properties

Tensile tests made at both room temperature and at 500 F show that the tensile strength of the bolts is comparable to the original material. These tests indicate also that rolled threads are slightly superior to ground threads both at room temperature and at 500 F. In every case, fracture occurred in the threaded section in a somewhat ductile manner.

Torque vs. tensile load on the bolt was measured by assembly of a bolt in a tensile machine, tightening the nut and recording the tensile load. These tests were made for each of the three type bolts, and for both type nuts. In addition, tests were made with and without lubricant. Graphs of the results show that for equal torque loads a much higher tensile load is obtained using the silver plated nuts than on the rhodium plated nuts. This indicates a much higher friction between titanium and rhodium plated nuts than between titanium and silver plated nuts. Also shown is the increase in tensile load for the same torque value when lubricant is added to reduce friction. The lubricant was an elevated temperature lubricant containing collodial graphite.

Galling

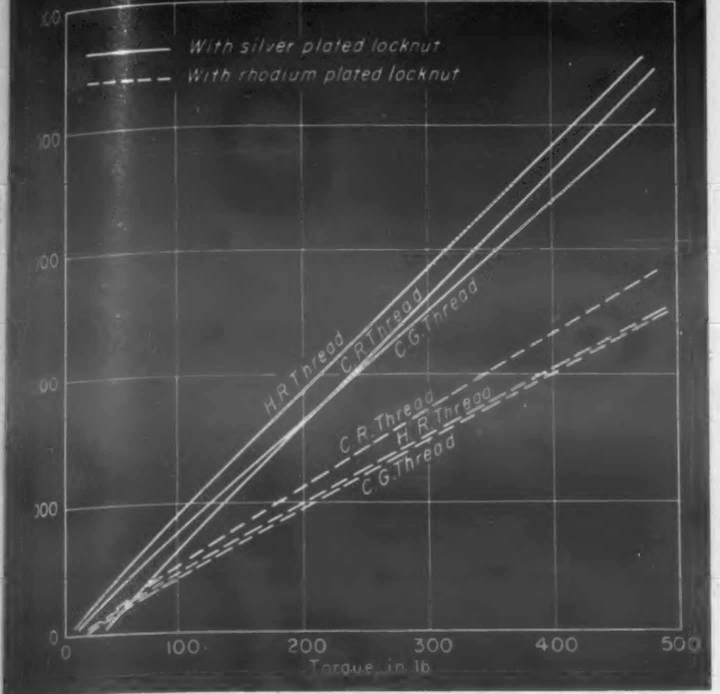
Galling tests were made by cyclically loading, heating and unloading

Relaxation Tests at High Stress (near yield stress)

	Load in Lb			
Thread	Initial	3 Hours	24 Hours	96 Hours
Cold Rolled	12,800	7800	—	4350
Cold Rolled	12,800	7200	5400	4180
Cold Rolled	10,650	9580	5200	—
Cold Rolled	12,800	7900	5700	4550
Hot Rolled	12,800	8200	5400	4500

Relaxation Tests at Low Stress (normal bolting stresses)

	Start		1 Hour		4 Hours		24 Hours		150 Hours	
Type Thread	Torque, In. Lb	Load, Lb	Torque, In. Lb	Load, Lb	Torque, In. Lb	Load, Lb	Torque, In. Lb	Load, Lb	Torque, In. Lb	Load, Lb
Cold Rolled	240	2100	240	2100	240	2100	240	2100	240	2100
Cold Rolled	400	3600	400	3600	400	3600	400	3600	390	3500
Cold Ground	240	2000	240	2000	240	2000	240	2000	240	2000
Cold Ground	400	3370	400	3370	400	3370	390	3270	390	3270
Hot Rolled	240	2100	240	2100	220	2080	220	2080	220	2080
Hot Rolled	400	3800	380	3600	380	3600	380	3600	380	3600

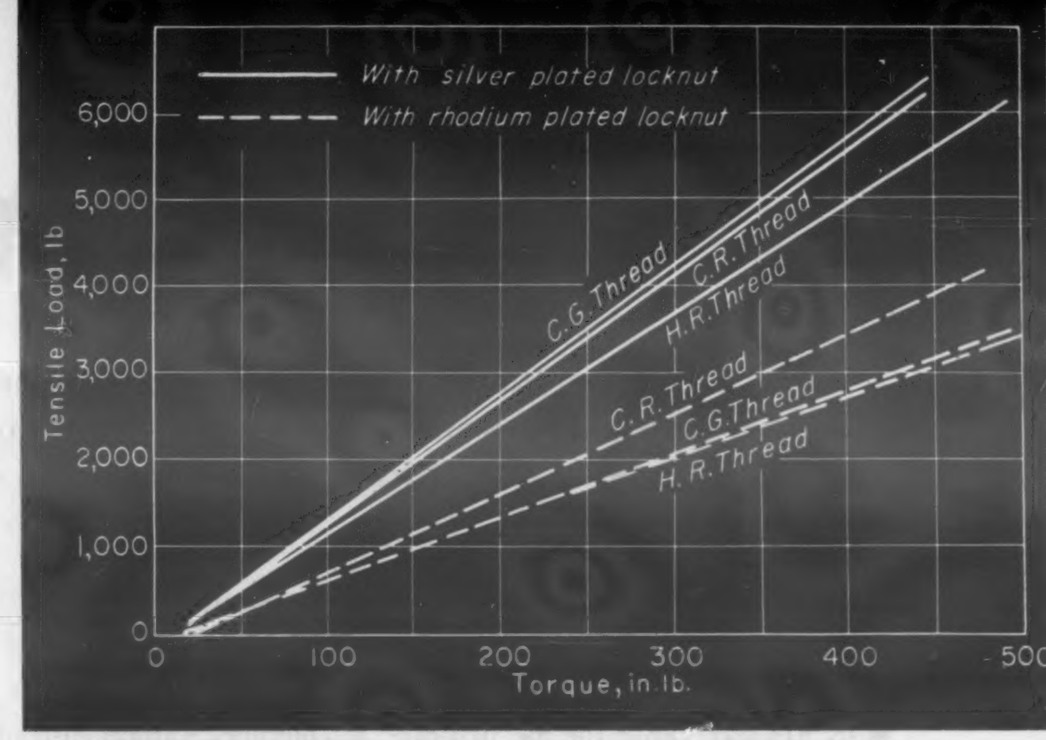


Relation between tensile load and torque for unlubricated bolts.

H.R. Hot Rolled

C.R. Cold Rolled

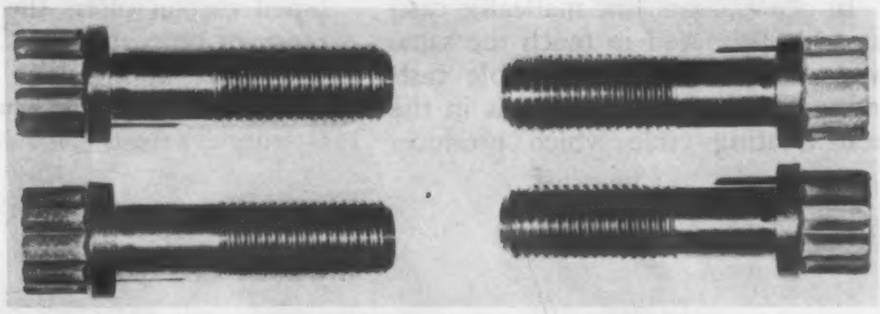
C.G. Cold Ground



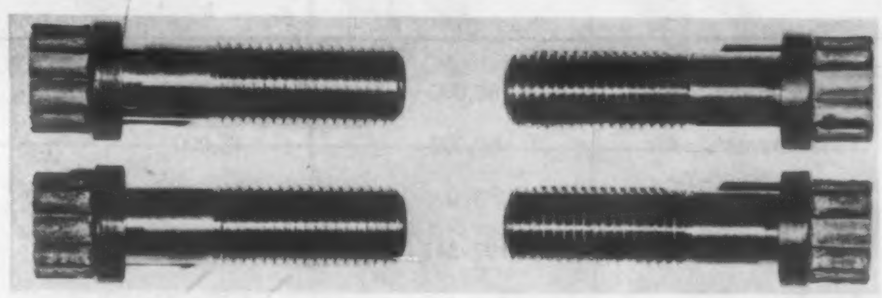
Relation between tensile load and torque for lubricated bolts.

Titanium Bolts Tested

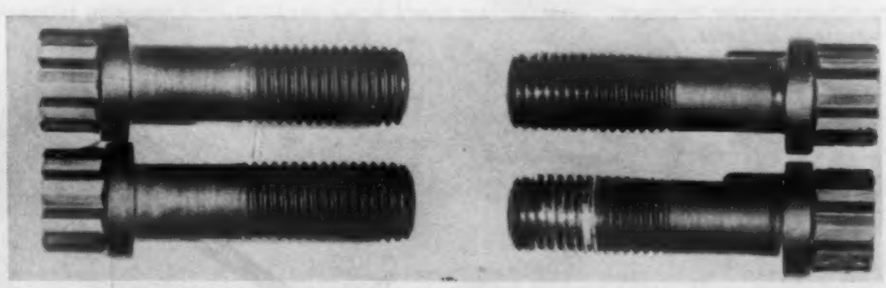
As Received **After Test**



Cold rolled threads. Upper right bolt, rodium plated locknut; lower right, silver plated locknut.



Cold ground threads. Upper right bolt, rodium plated locknut; lower right; silver plated locknut.



Hot rolled threads. Upper right bolt, rodium plated locknut; lower right, silver plated locknut.

a bolt and locknut assembly. A greater tendency for galling exists between the titanium bolts and silver plated nuts than between the titanium bolts and rhodium plated nuts. The break-away torque is much higher for silver plated nuts than for rhodium plated nuts while tensile load data show that the opposite should be true concerning break-away torque since friction is greater between the titanium and the rhodium plated nuts than between the titanium and the silver plated nuts. Higher break-away torque shows also that ground threads have a higher galling tendency than the rolled threads.

Relaxation Characteristics

Two groups of relaxation tests were made, one at relatively low stress (normal operation for the bolts) and the second at a high stress approaching the yield strength. Stress rupture tests were also made. Silver plated nuts were used and the tests were made at room temperature. Under relatively low stress (up to 400-in. lb of torque which is equivalent to about 5000 lb tensile load) very little, if any, relaxation occurred in 150 hr. These tests were made by loading bolts to various amounts of torque and checking the loosening effect with time, thus giving a measure of relaxation.

Relaxation at higher stress was measured by loading bolts to near their yield points, holding under load and periodically checking to see how rapidly the load decreased due to relaxation. With stresses of this order of magnitude, relaxation does occur, however, the test method is accurate only within 10 or 15%.

Stress-Rupture

Several stress rupture tests were made at 500 F. In all cases the bolts successfully withstood a load of 13,800 lb for a 4-hr period. Since these tests required long time machine tie up more extensive testing was not done; however, the normal notched rupture properties will apply for such an application.

Where Pearlitic Malleable Irons

Stronger than standard malleable and approaching the properties of forgings, this versatile material is competing favorably with other metal forms in the automotive, ordnance, aircraft and other industries.

by CARL F. JOSEPH, Central Foundry Div., General Motors Corp.

● IN RECENT YEARS the use of pearlitic malleable iron castings has expanded because it is filling the need for a cast material that is stronger than standard malleable and approaches the properties of good-grade steel forgings.

In general, pearlitic malleable castings are produced in much the same way as conventional malleable castings. The major difference is in the heat treating cycle which produces combined carbon instead of free carbon in the matrix. This combined carbon gives the pearlitic grades their characteristic properties. The higher the combined carbon, the stronger, harder, and less ductile the casting. Thus, control of the amount of combined carbon offers the user a wide range of properties.

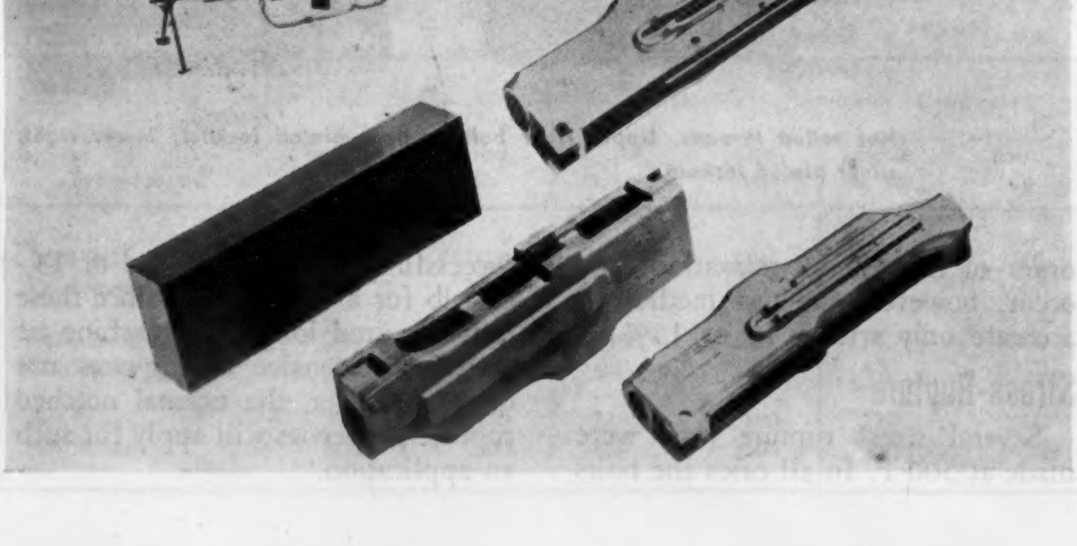
Typical applications of pearlitic malleable iron cover a wide field. It is truly a versatile material, combining the simplicity and adaptability of a casting with the strength and reliability of a forging. It is replacing many forgings, stampings and weldments in the automotive, refrigeration and allied industries.

Illustrated here are some of the applications showing the outstanding properties of this material and the reasons why castings are advantageous to other existing methods of fabrication.

Minimum Mechanical Properties of Pearlitic Malleable Irons

	Class A	Class B	Special
Tensile Strength, psi	80,000	70,000	100,000
Yield Strength, psi	60,000	48,000	80,000
Elongation, % in 2 in.	3.0	4.0	2.0
Brinell Number	197–241	163–207	241–269
Brinell in mm.	3.9–4.3	4.2–4.7	3.7–3.9

NOTE:
Higher tensile and yield strengths can be obtained from any of the grades shown by use of a conventional quench-and-temper treatment. This increase would be accompanied by a reduction in toughness and a likely increase in hardness.



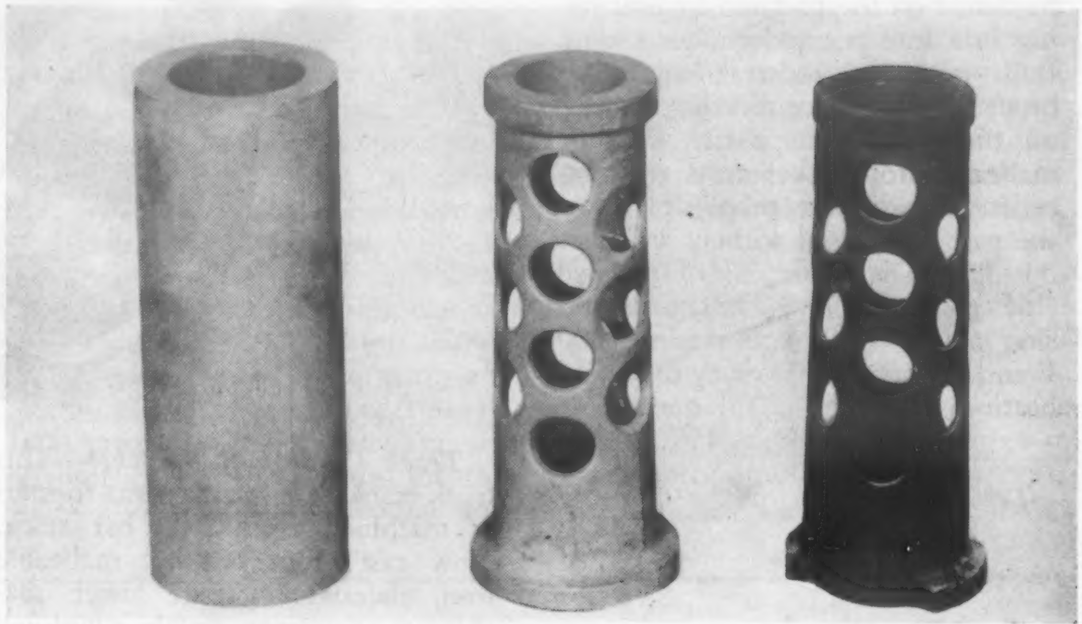
Good Machinability

In general, the machinability of pearlitic malleable iron is 10 to 30% better than steel forgings of the same Brinell hardness. The castings shown are representative of parts showing a reduction in machining time. This is accomplished by coring out hollow sections and by using 2 deg draft angles compared to the customary 7 deg used on forgings. One of the advantages of castings is that the metal can be placed exactly according to the needs of the finished part so that the amount of machining necessary is minimized. Up to 50% in man hours of machining time is being saved where pearlitic malleable iron castings have supplanted steel forgings. Tool life is substantially increased due to easier machinability and the reduction of excess finish stock.

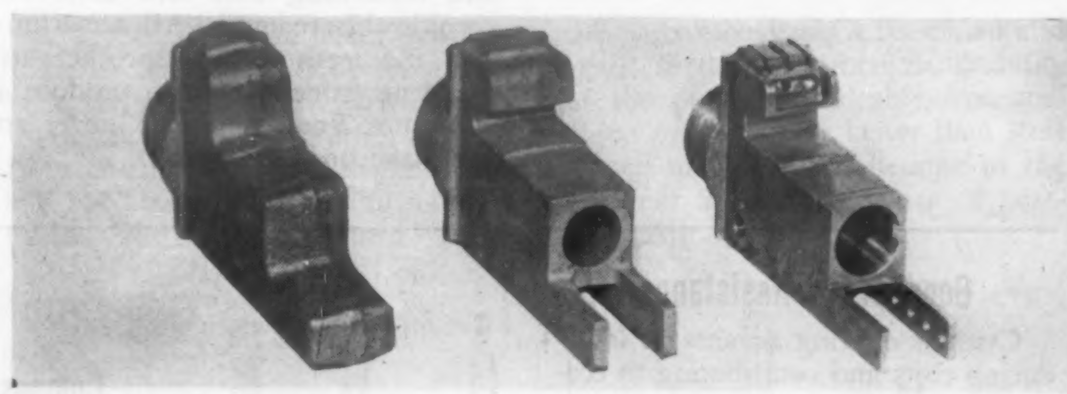
Receiver for Browning Automatic Rifle—This part formerly was machined from SAE 1035 bar stock weighing 25 lb. The casting for this part weighs 10 lb, the finished, machined receiver slightly more than 3 lb. Recently a few shell molded castings weighing approximately 5 lb have been supplied which require practically no machining on the outside and very little on the inside.

Can Be Used To Advantage

Barrel Support, .50 Caliber Gun—Part formerly was machined from an SAE 1020 steel tubing weighing 20 lb. By redesigning the part, a 5.6 lb casting was machined to a 4.5 lb finished component. Two advantages in using pearlitic malleable iron over steel were obtained: 1) a greatly reduced number of machine tools were required to produce this part in large quantities; 2) it was possible to eliminate the bronze bushing between the barrel and the support since steel rubbing on steel would wear quickly due to the recoil action after each shot. Pearlitic malleable iron has bearing-like qualities and reduces metal-to-metal wear to a minimum.



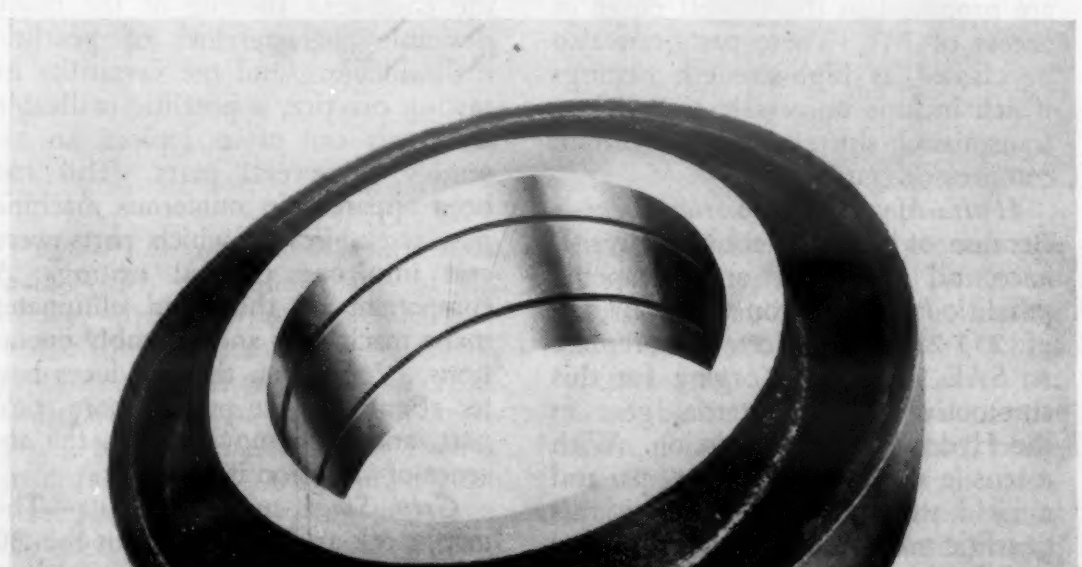
Trunnion Block, .50 Caliber Gun—Part, formerly machined from a 20 lb SAE 1035 steel forging, weighs 6 lb when ready for assembly. The casting weighs 9.9 lb. Thirty-five percent less machining time was required to machine this casting as compared to the forging.



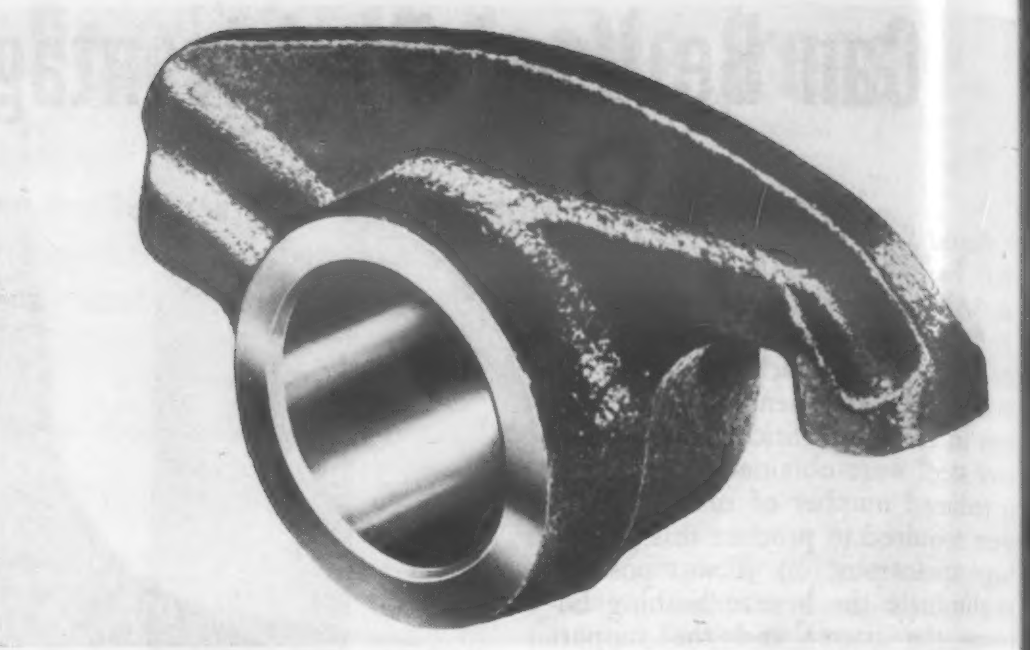
Selective Hardening

Castings illustrating selective hardening comprise trolley wheels, rocker arms, truck crankshaft sprockets, some small engine crankshafts, transmission shifter yokes and many others. This property of localizing hardening is utilized in flame hardening or induction hardening of these parts. Liquid bath hardening can also be used on lower hardness pearlitic malleable iron by allowing a longer time at the higher temperature. This produces enough combined carbon to give a minimum Rockwell C of 50 when oil quenched.

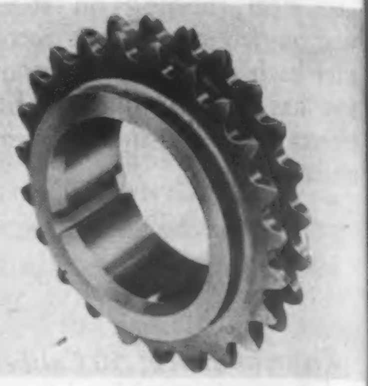
Truck Trolley Wheel—The manufacturer replaced a forged SAE 1040 steel trolley wheel with pearlitic malleable iron in the 197-241 Brinell range and induction hardened the rim to 50 Rockwell C minimum to a 1/16-in. case depth. Accelerated life tests show excellent wear resistance compared to the forging.



Automotive Rocker Arms—The pad end of the automobile rocker arm must be hardened for wear resistance. Originally most rocker arms were SAE 1020 steel carburized and hardened. Some were SAE 1035 steel hardened on the pad end by immersing in a lead pot and oil quenching. Both types of rockers required a bronze bushing for bearing surface on the rocker arm shaft. Pearlitic malleable iron rocker arms with excellent non-seizing properties allow the part to be used without a bronze bushing. The hardening of the pad end can be accomplished by immersion in a salt or lead pot around 1600 F and oil quenching, or by induction heating the pad and oil quenching.



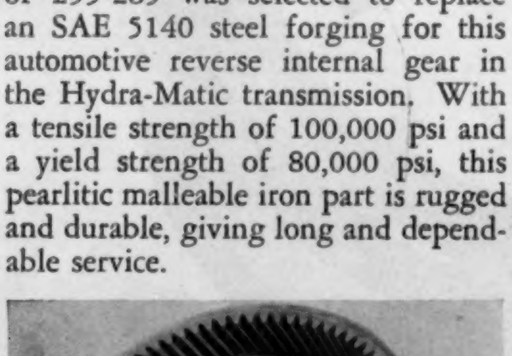
Truck Crankshaft Sprocket—This truck crankshaft sprocket was formerly machined from steel bar stock. Now cast from pearlitic malleable iron, material costs are lower, machining operations greatly simplified and machining time and costs are considerably reduced. After machining, the teeth of the sprocket are acetylene flame treated to produce a minimum Rockwell C 55, after an automatic quench in oil.



Good Wear Resistance

Castings offering advantages in reducing costs and contributing to economical production are the parts which must have good wear resistance. These components include automatic transmission gears, transmission pistons and, in general, parts which are produced in the Brinell range in excess of 241. These parts can also be classed as high-strength castings which include universal joints yokes, transmission shifter yokes and certain compressor crankshafts.

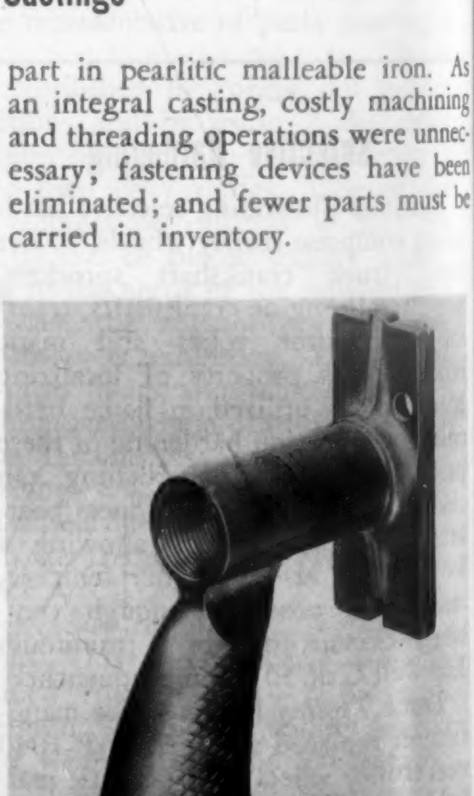
Hydra-Matic Transmission Gear—Because of its excellent wear resistance, oil quenched and tempered pearlitic malleable iron with a Brinell of 255-285 was selected to replace an SAE 5140 steel forging for this automotive reverse internal gear in the Hydra-Matic transmission. With a tensile strength of 100,000 psi and a yield strength of 80,000 psi, this pearlitic malleable iron part is rugged and durable, giving long and dependable service.



Composite Castings

Castings which can be engineered as a composite of several parts are receiving considerable attention from the engineer. Because of the many desirable characteristics of pearlitic malleable iron and the versatility of casting practice, a pearlitic malleable iron part can often replace an assembly of several parts. This has been apparent in numerous machine gun assemblies in which parts were cast into one integral casting. A component of this kind eliminates many machining and assembly operations. Very often this produces better alignment, the part is more compact, and on a moving part, the absence of vibration is apparent.

Grip, Stock and Back Plate—The grip, stock and back plate for the .30 caliber machine gun was formerly a three-part assembly requiring six fastening devices. The grip was an aluminum casting; the stock was machined from steel tubing; and the back plate was a forging. Now, the entire assembly is cast in a one-piece part in pearlitic malleable iron. As an integral casting, costly machining and threading operations were unnecessary; fastening devices have been eliminated; and fewer parts must be carried in inventory.



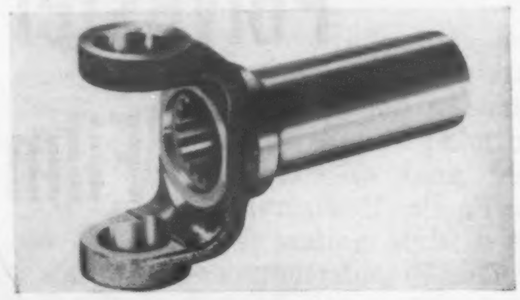
High Yield Strength

Castings receving increasing attention in automotive engineering are those of the high yield strength type. As the properties of pearlitic malleable iron are better understood, the uses of this class of parts will be greatly expanded. High yield strength with good machinability is a rare combination offered by pearlitic malleable. Liquid quenching or tempering gives a minimum of 80,000 psi yield strength.

Universal Joint Yokes—A number of leading automobile manufacturers were using SAE 1145 or 1151 steel forgings for the highly-stressed universal joint yokes that form a vital link in the propeller shaft assembly of automobiles. Broaching the splines on these yokes produced a load of 11,000 lb. On the SAE 1151 steel forgings, the broach life was 3000 pieces with a low of 100 pieces per tool grind and an average of 500 to 600 pieces per tool grind. On SAE 1145 steel the broach life was from 9000 to 10,000 with average of 800 to 900 pieces per tool grind.

At present, a manufacturer who has changed to pearlitic malleable iron uses an oil quenched and tempered casting with a Brinell of 241-269. In this case, the broach load has been reduced to 5500 lb, obtaining a broach life of 15,000 to 20,000 pieces with a high of 3000 pieces per tool grind and an average of 1600 to 1800 pieces per tool grind. The use of pearlitic melleable iron for the yokes also results in smoother and more accurate splines.

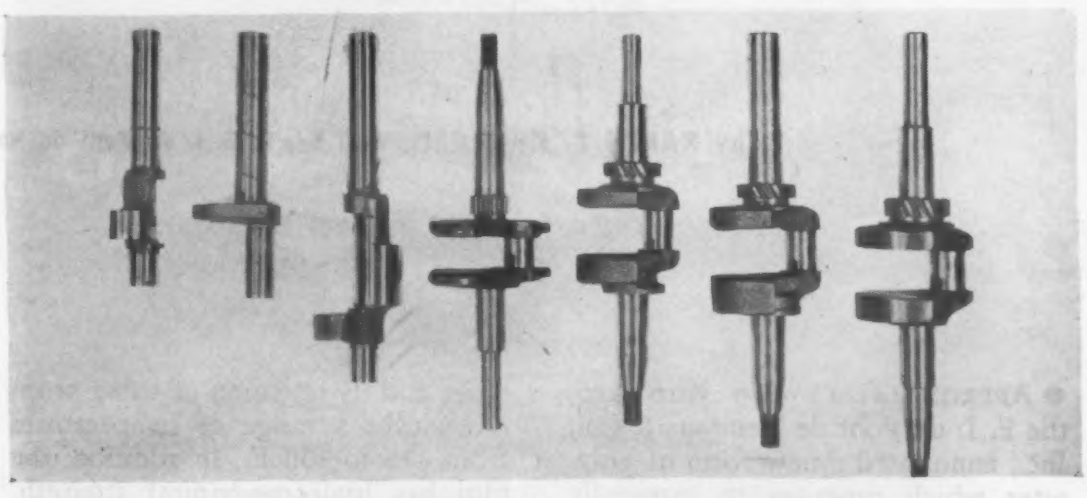
Many other machining advantages are claimed for the pearlitic malleable iron universal joint yoke. Drilling and reaming the cross holes have shown an improvement over the steel forging of from 50 to 300% in tool life. In grinding shank, it is easier to hold the required tolerance; this is accomplished with a reduction of 60% in number of wheel dressings.



Excellent Finishing Qualities

Excellent finishing qualities were apparent in the manufacture of .30 caliber and .50 caliber Browning machine guns. There were 16 pearlitic malleable iron parts used on the .30 caliber and 28 parts on the .50 caliber machine gun. The .30 caliber was supplied by five manufacturers and the .50 caliber by seven manufacturers, all using pearlitic malleable iron parts. The parts were shipped from one manufacturer to the other and 1000 to 10,000 round firing tests made. The guns were torn down, the parts mixed up, reassembled and again fired. The interchangeability of the pearlitic malleable iron machine parts was far better than steel forged machine parts because of the excellent finishing qualities of pearlitic malleable iron.

Diesel Piston—A casting with excellent finishing qualities and high strength characteristics, pearlitic malleable iron makes an ideal material for heavy duty Diesel pistons. The metal can be machined to a very smooth surface and polished to a mirror-like finish, reducing friction and wear to a minimum.



Small Engine Crankshaft—One part which embodies many of the above advantages of pearlitic malleable iron is a crankshaft for refrigerators and small engines. The crankshafts of small two and four-cycle engines, built by a number of leading manufacturers, were machined from steel forgings up to a few years ago. To effect a saving in raw material and production costs, these manufacturers changed to a pearlitic malleable iron casting in a Brinell range of 197-241. The casting in most cases costs less than a forging. Better weight and metal distribution, small draft angles and better machining were all factors in reducing production costs. The heat treatment varied between the various manufacturers. Some oil quenched and tempered the casting to a definite Brinell range. Others preferred to induction harden or flame harden certain areas of the shaft. Pearlitic malleable iron, being a versatile product, allowed the manufacturer a wide range of properties suited for his particular needs, which he was able to obtain by known standard heat treating methods.

Pearlitic malleable iron also weighs about 8% less than a steel forging of the same dimensions, thereby producing a lighter part. Good damping capacity will result in more quiet operation.

New Polyester Film

- ***Will be in large scale production soon***
- ***Has high strength, heat and corrosion resistance***
- ***Will find many electrical applications***

The film, in either transparent or translucent form, has a tensile strength of 25,000 psi.

by **RALPH C. KRUEGER**, Film Dep't., E. I. du Pont de Nemours & Co., Inc.

● APPROXIMATELY two years ago, the E. I. du Pont de Nemours & Co., Inc., announced a new form of polyester which promises to materially broaden the field of industrial application of this type of resin. The product, Mylar polyester film, is a film made from polyethylene terephthalate, the polymer formed by the condensation reaction between ethylene glycol and terephthalic acid. Tough, durable and impermeable to a number of organic and inorganic gases, the film is now produced in limited quantities in seven thicknesses, ranging from 0.00025 to 0.0075 in. A plant now under construction is expected to be in production late this year or early in 1955.

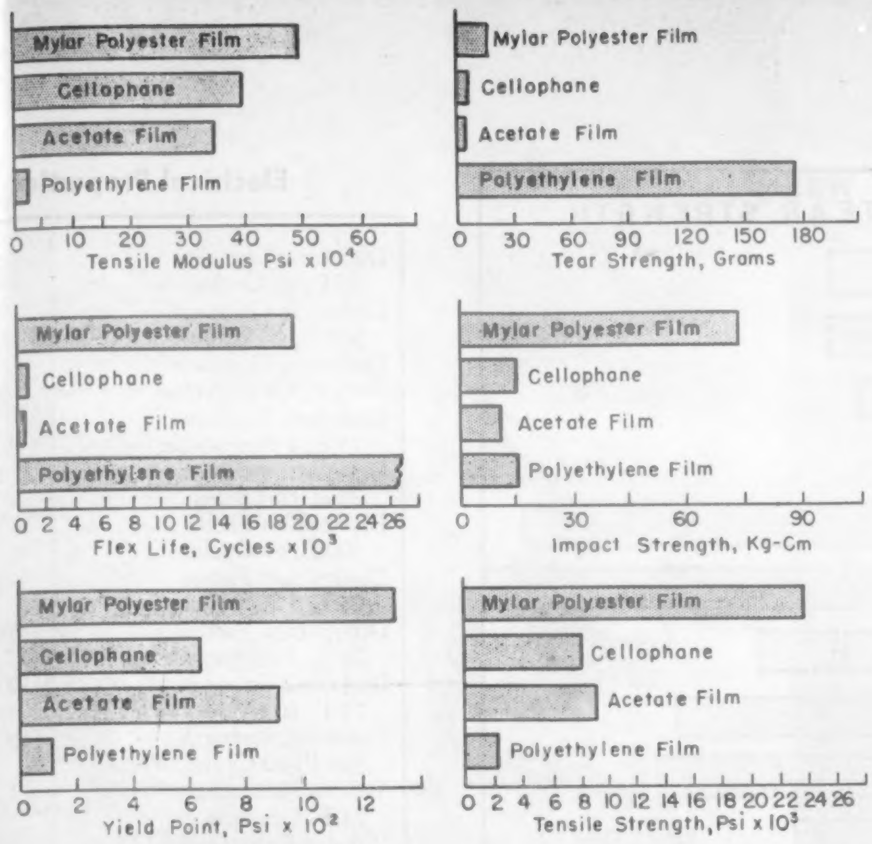
The largest single market for the film is expected to be the electrical field, due to its high insulation properties and its retention of these properties over a range of temperatures from –75 to 300 F. In addition, the film has high mechanical strength, long-term resistance to heat, and chemical inertness, all of which are required in, for example, electric motor insulation. The film can also be vacuum metallized with aluminum for use in capacitors or condensers. The metal can be deposited on the film in layers measuring as little as 125 Angstroms.

Physical Properties

As shown in the accompanying charts, Mylar has a tensile strength two to three times that of cellophane or acetate film. And though it is relatively stiff, with a modulus higher than that of cellophane or acetate, it has a much longer flex life than either of the two. The combination of good impact strength, flex life, stiffness and tear resistance increases the mechanical durability of the film.

Up to the yield point of a typical sample of film, which is around 13,000 psi with a strain of 5 to 6% elongation, the stress is proportional to the strain; however, beyond this point the film exhibits viscous flow, stretching appreciably until at about 70 to 80% strain, it reinforces up to the break point at around 23,000 psi. These values, of course, change slightly with the different gages of material.

The effect of temperature on the physical and mechanical properties of the film is small over the range of –4 to 176 F. No embrittlement will occur down to –76 F, and though more



Properties of new polyester film as compared to other DuPont thin films.

marked changes in tensile properties are noted above 212 F, the film retains useful properties up to 300-340 F. The tensile strength decreases about 650 psi for each 18 deg F increase in temperature between 0 and 176 F, while above the second order transition temperature of 176 F, it decreases about 1000 psi for each 18 deg F increase up to the melting point at 480-485 F.

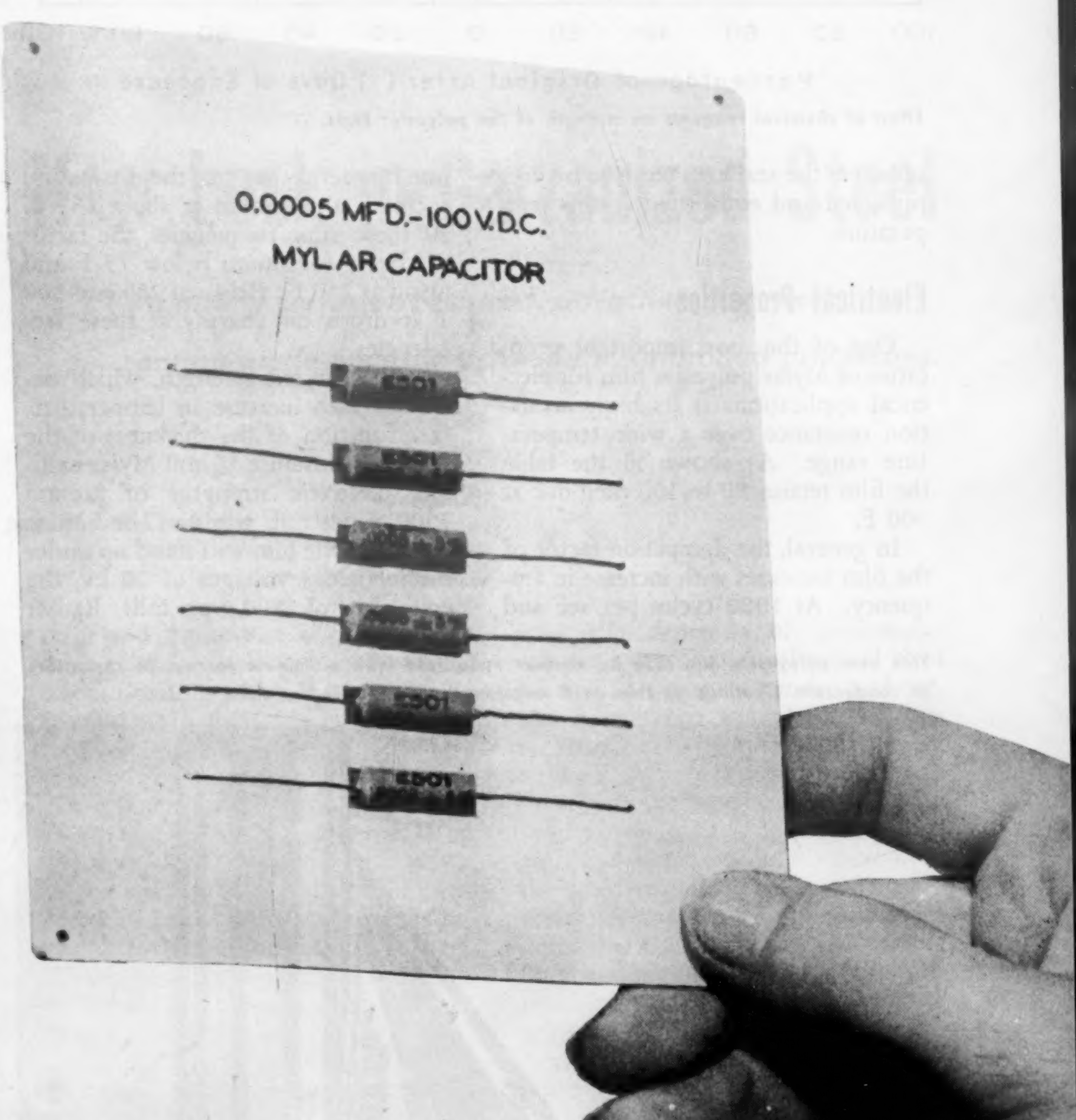
Light transmission curves for soft window glass and Mylar are similar, the latter cutting off at a slightly lower wave length. It transmits more than 90% of incident light in the visible region of the spectrum, cutting off sharply in the ultraviolet at 3150 Angstroms. Celophane transmits much of the so-called biologicaly active region of the spectrum (2950-3,150 Angstroms), while Mylar absorbs strongly in that region.

Results of flammability tests are erratic and inconclusive, since the material melts and drips during the tests; however, from a qualitative point of view Mylar appears to burn less readily than films made of cellophane or acetate. Since sealing Mylar with heat requires a temperature of around 465 F, satisfactory seals are difficult to

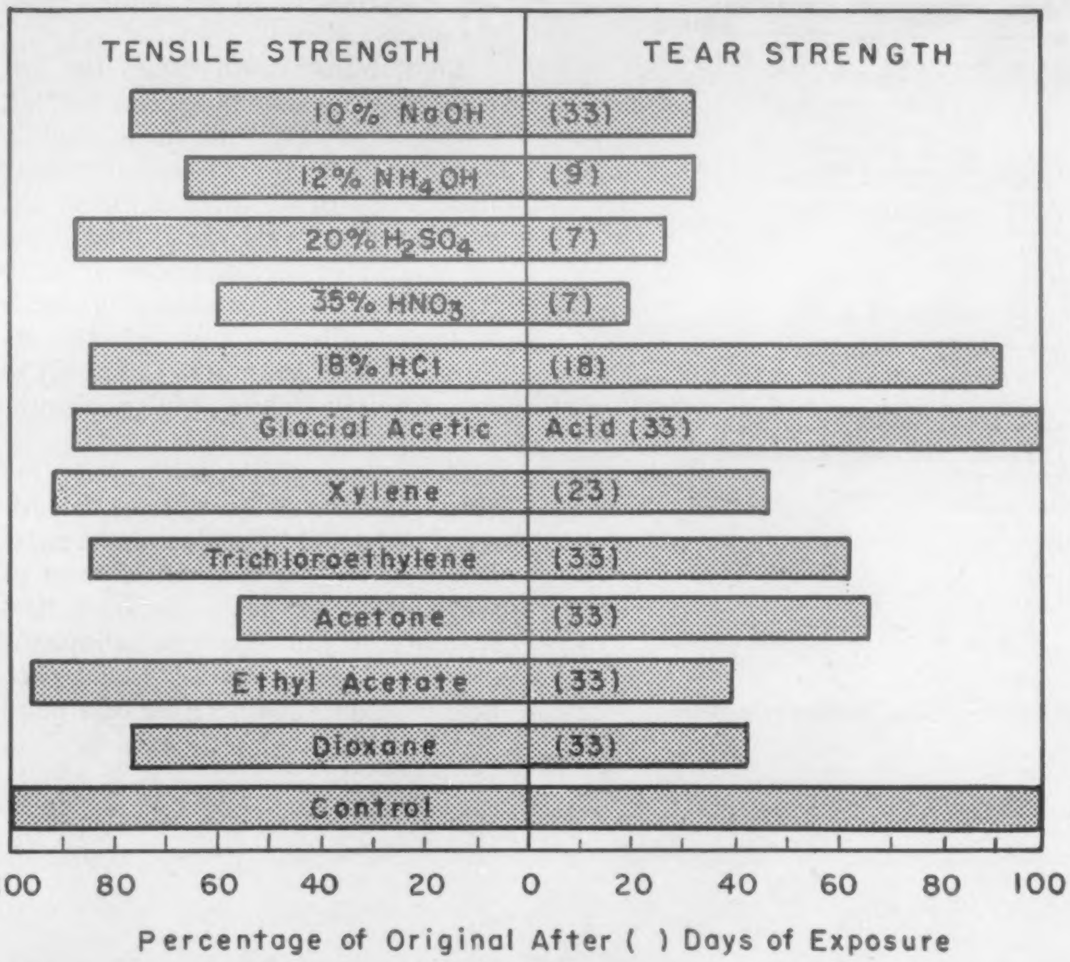
General Physical Properties

Melting Point, F	480–485
Specific Gravity, Gms/cc	1.38–1.39
Refractive Index, ⁿD25	1.655
Area Factor, Sq in./lb/mil	20,000
Ten Str, Psi	17,000–25,000
Ten Mod, Psi	450,000–600,000
Impact Str, Kg-cm	70 (1 mil)
Break Elongation, %	70–130 (1 mil)
Tear Str, Gms	18 (1 mil)
Flex Life, 0 F, cycles	20,000 (1 mil)
Bursting Str, Lbs	45 (1 mil)
Bending Recovery, % (immediate)	43 (1 mil)
Bending Recovery, % (60 sec)	51 (1 mil)
Thermal Coefficient of Linear Expansion, F	20×10^{-6}
Humidity Coefficient of Linear Expansion, % R.H.	11×10^{-6}
Coefficient of Thermal Cond, Cal/cm/sec/C	3.63×10^{-4}
Oxygen Permeability, G/100m²/hr	0.90 (1 mil)
Water-vapor Permeability, 86 F G/100m²/hr	160 (1 mil)
Moisture Absorption, % (100% R.H.)	0.3
Shrinkage 302 F, %	3–5
Fungus Resistance	Excellent
Corrosive Effect on Copper	Negligible

NOTE:
Data shown are average values and should not be used for specifications.



The good electrical properties of Mylar are utilized in these capacitors. The film used here is 0.00025 in. thick.



Effect of chemical reagents on strength of the polyester films.

obtain as the seal area tends to become puckered and embrittled at this temperature.

Electrical Properties

One of the most important properties of Mylar polyester film for electrical applications is its high insulation resistance over a wide temperature range. As shown in the table the film retains 80 to 100 meg-mic at 300 F.

In general, the dissipation factor of the film increases with increase in frequency. At 1000 cycles per sec and one megacycle per sec, the dissipation factor is a minimum at about 165 F. At these same frequencies, the factor reaches a maximum below 75 F and again at 250 F. Between 250 and 300 F it drops off sharply at these frequencies.

The dielectric strength, which decreases with increase in temperature, is a function of the thickness of the film. For instance ¼-mil Mylar exhibits dielectric strengths of around 7500 v per mil, while a 7 mil thick section of the film will stand up under instantaneous voltages of 20 kv, the equivalent of 2800 v per mill. Rather rapid dielectric fatigue or failure will result from operating under appreciable amounts of internal a.c corona. The film in air will be attacked to some extent by corona at 300 to 400 volts rms a.c. If a.c. potentials greater than these are involved, impregnation with oil or varnishing with other suitable materials is necessary.

Electrical Properties

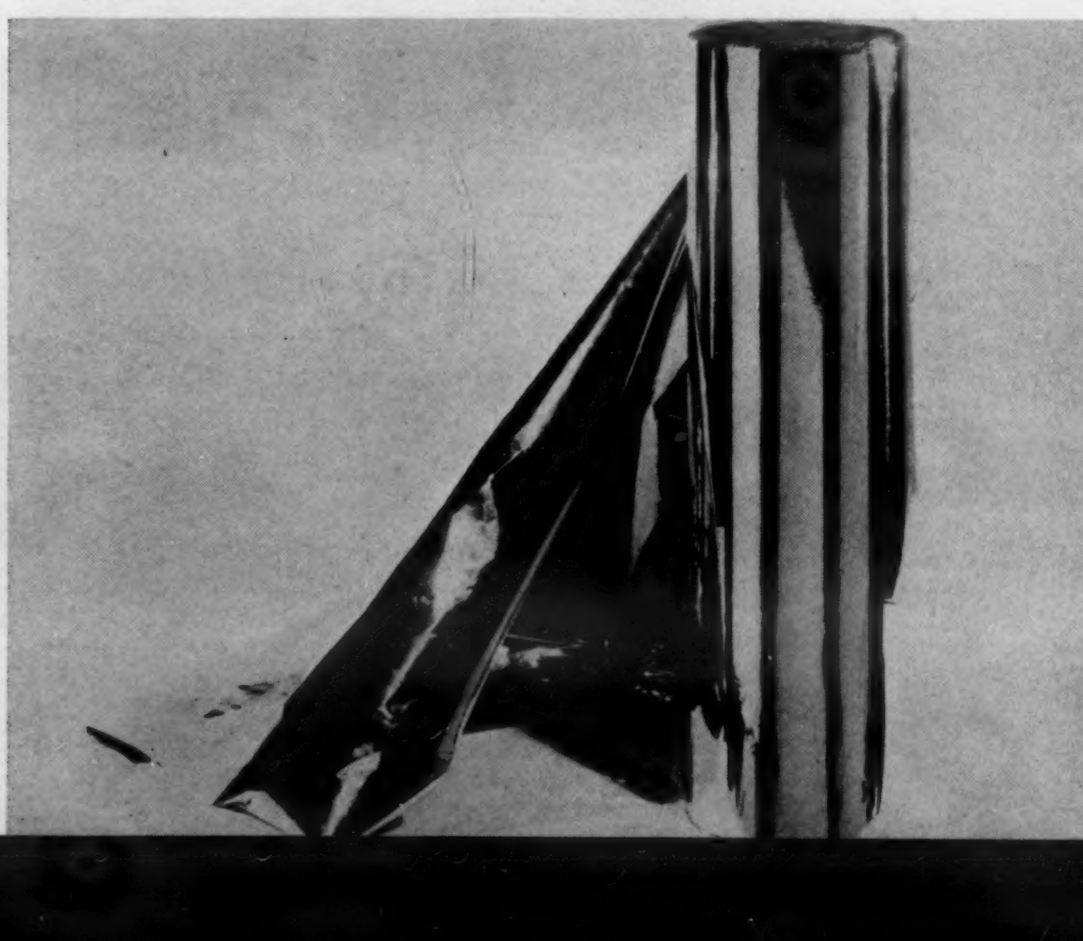
Dielectric Constant 75 F, 60 Cycles	3.16
Dielectric Constant 300 F, 60 Cycles	3.7
Dielectric Constant 75 F, 1 Kilocycle	3.12
Dielectric Constant 75 F, 1 Megacycle	2.98
Dissipation Factor 75 F, 60 Cycles	0.0021
Dissipation Factor 300 F, 60 Cycles	0.0064
Dissipation Factor 75 F, 1 Kilocycle	0.0047
Dissipation Factor 75 F, 1 Megacycle	0.016
Dielectric Strength 75 F, 60 Cycles, V/mil	4500 (2 mil)
Dielectric Strength 300 F, 60 Cycles, V/mil	3150 (2 mil)
Volume Resistivity 75 F, Ohm-cm	1×10^{19}
Volume Resistivity 300 F, Ohm-cm	1×10^{13}
Surface Resistivity 75 F, 0% R.H., Ohms	10^{12}
Surface Resistivity 75 F, 100% R.H., Ohms	4.8×10^{11}
Insulation Resistance 266 F, Meg-mics	800–1000
Insulation Resistance 300 F, Meg-mics	80–100

Applications

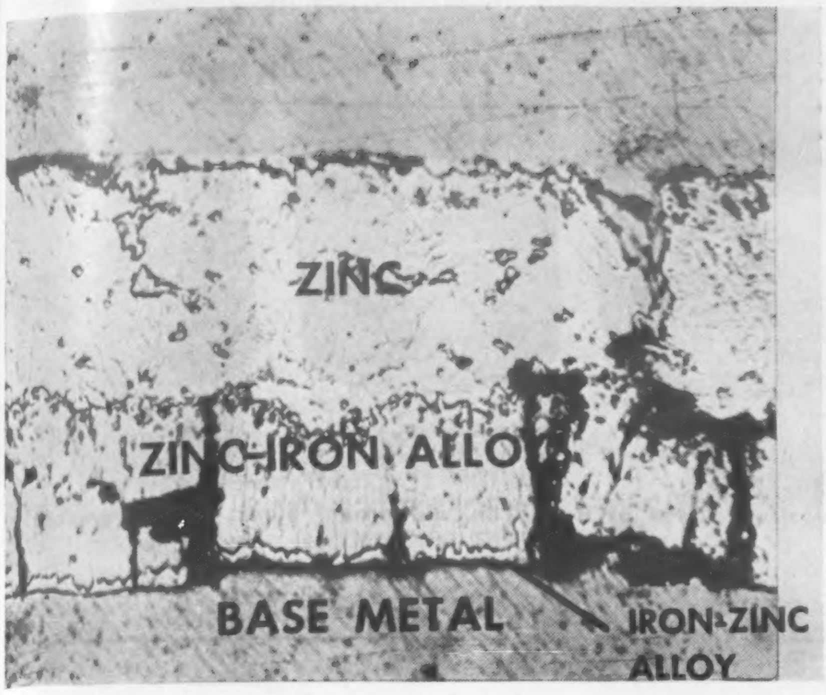
The physical, electrical and chemical properties of Mylar polyester tape promise a variety of applications in several fields. It is now being used by one manufacturer as phase insulation in a line of motors. It is also an attractive material as a dielectric in capacitors, tape insulation for motor and generator field coils, insulation on magnet wire, barrier and insulation tapes in cable construction, and backing for mica splitting and integrated mica.

In the non-electrical field, it is showing promise as a base for magnetic sound-recording tapes and pressure-sensitive industrial tapes; cap lining material; steel and fiber drum lining material; protective covers; protective wrap for pipe line insulation, such as glass fiber, cork, etc.; industrial laminates; storm windows; plastic glazing for agricultural buildings, etc.; and special packaging applications.

This new poleyester film may be vacuum metallized with aluminum for use in capacitors or condensers. Coatings as thin as 5 angstroms are possible.

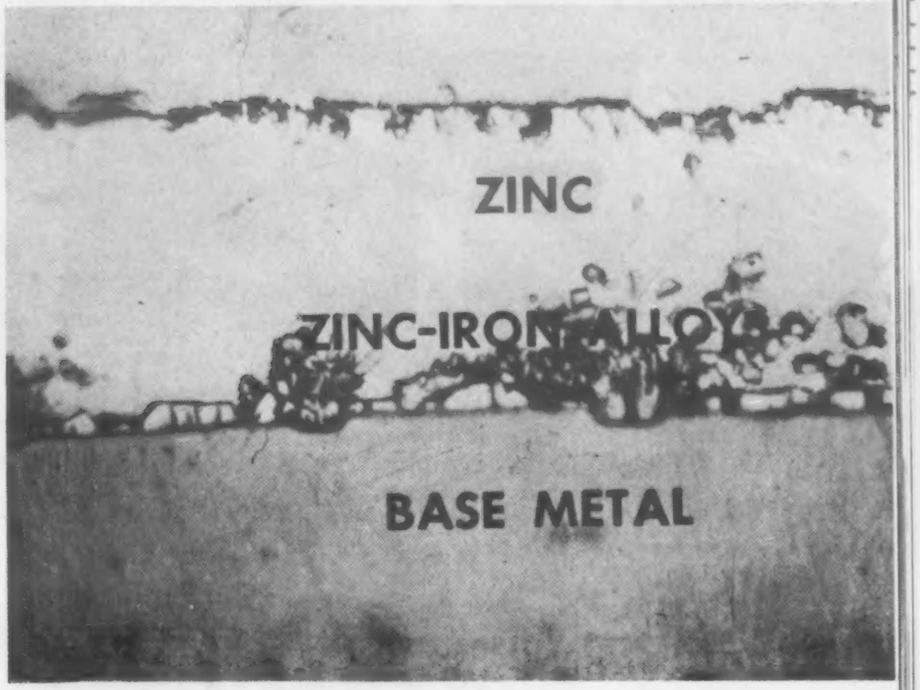


OLD



Cross-section of the old type coating after the metal was stretched only 15%. Dark areas are cracks that spread from the brittle alloy layer, causing the coating to flake or peel off.

NEW



Cross-section of the new type coating after 20% stretching. There is no brittle alloy layer and the zinc coating adheres tightly to the base metal.

The New Look in Galvanized Steel

. . . a highly corrosion resistant, attractive and workable coating made possible by modern, controlled processing.

by ERNEST W. HORVICK, American Zinc Institute

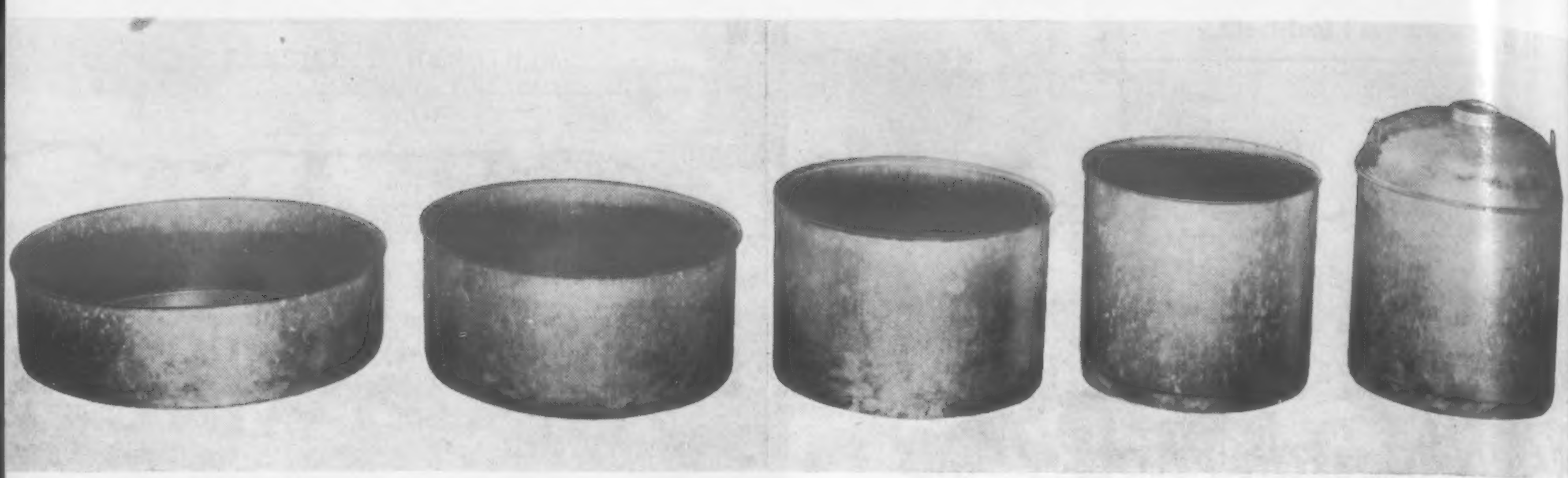
● SIGNIFICANT CHANGES in galvanizing methods in recent years have resulted in a coated steel much more versatile than its predecessor material. Because of wartime and postwar difficulties in obtaining zinc, some of these improvements are not generally realized throughout industry.

Corrosion has always been a problem for users of steel and protective coatings of zinc have been used for more than a century. Their importance has grown along with expanding applications for steel products and increasing awareness of the destructiveness of unchecked corrosion. Zinc is used as a protective coating more than any other metal. It is easy to apply, is inexpensive, is readily available, lends itself especially well to continuous processing, has color and appearance satisfactory for most purposes and provides a hard smooth coating which is comparatively resistant to abrasion. Furthermore, it gives double protection. In addition to providing a mechanical barrier of relatively corrosion-resistant metal, zinc protects steel by means of galvanic action. As a result, rusting of the steel at bare spots or cut ends is avoided as long as enough zinc remains to be preferentially attacked. When sustained galvanic protection is needed, of course, zinc coatings must be fairly heavy.

Hot Dipped Galvanized Steel

Galvanizing of steel is done by electroplating or by the more widely used hot dip process. In order to meet the demands of present-day industry, hot dipped galvanized steel has had to meet new standards of corrosion resistance, workability and surface quality. The zinc coatings must be thick enough and uniform enough to protect the base against corrosion for an extended period of time. The coating must be highly adherent to the base metal so that it will remain intact, regardless of the degree of deformation. Both base and coating must be highly ductile so the material can be formed into complicated shapes.

Adherence and ductility of the zinc coating are dependent on the condition of the base sheet surface prior to galvanizing and the nature of the zinc-steel interface. These, in turn, are affected by process variables such



WHAT CAN BE DONE—This container, made of hot dipped galvanized steel, started as a $26\frac{1}{8}$-in. dia circular blank. Finished product, after four draws, is $11\frac{1}{4}$ in. in dia and $10\frac{1}{2}$ in. deep.

as steel surface preparation, composition of the molten zinc and temperature of the bath.

The steel surface must be free of any foreign material that will prevent wetting by the molten zinc. Even the slightest film of rust incurred in drying will result in low adherence. Ideal surface preparation by the conventional method of acid pickling is difficult; underpickling does not completely remove the oxide film, and overpickling often leads to hydrogen embrittlement and necessitates a boiling operation. This surface problem can be largely avoided by using controlled atmospheres in heat treating thus preventing the occurrence of tough oxide films.

The reaction between molten zinc and steel results in the rapid formation of alloy layers, their thickness and structure being determined by composition and temperature of the metals. Adherence of the zinc coating drops as thickness of the alloy layer increases. The iron-zinc alloys, especially those high in iron content, are quite brittle and not amenable to deformation. Good ductility requires that the growth of these alloy layers be inhibited or, even better, completely avoided. Addition of aluminum to the zinc bath retards the beginning of the reaction between zinc and steel and thus inhibits alloy formation during the coating operation.

Bath temperature influences not only the depth of the alloy layer but also the formation of dross. To produce clean, uniform coatings, it is necessary to maintain temperature at an optimum level.

Today's continuous galvanizing lines incorporate careful control of these process variables. Control of steel surface quality, for instance, begins in the annealing process. Use of open annealing with a reducing atmosphere, instead of the box annealing methods formerly used in galvanizing, eliminates the need for acid pickling, washing and fluxing. The uniformly clean and unadulterated steel surface is more receptive to the wetting action of the molten zinc. Since a rough surface is no longer needed for adherence, hydrogen embrittlement resulting from deep etching is avoided.

The improved surface also obviates the necessity for adding sulfur and phosphorus to the steel to promote adherence. Since addition of these elements reduces ductility, good adherance and good ductility are made more compatible than heretofore.

Zinc bath composition and temperature are also closely controlled in the continuous galvanizing line. Heat input to the zinc bath is supplied principally by the hot strip in the cooling phase of the annealing cycle. Automatic instrumentation compensates for the width of the strip and insures that the steel, when immersed in the bath, is at a temperature that will allow instantaneous wetting and bonding with the zinc. Close temperature control, together with the short immersion time and controlled aluminum additions, limit the formation of the undesirable nonzinc alloy layers.

A number of factors combine to limit dross formation in the continuous galvanizing line so that essentially pure zinc coats the steel. Pickle salts are eliminated and the speed of operation reduces the reaction time between steel and molten zinc. Furthermore, the method of heat supply is such that high temperature contact of zinc with the galvanizing vessel is avoided, and whatever dross is formed settles to the bottom and is not agitated and circulated throughout the zinc bath.

The product of today's continuous galvanizing line offers not only good corrosion resistance but also an ease of fabrication that makes it well adapted to complex shapes of good appearance. The good adherence and ductility of the zinc coating enable

Classes of Hot Dip Coatings

ASTM A93-52T

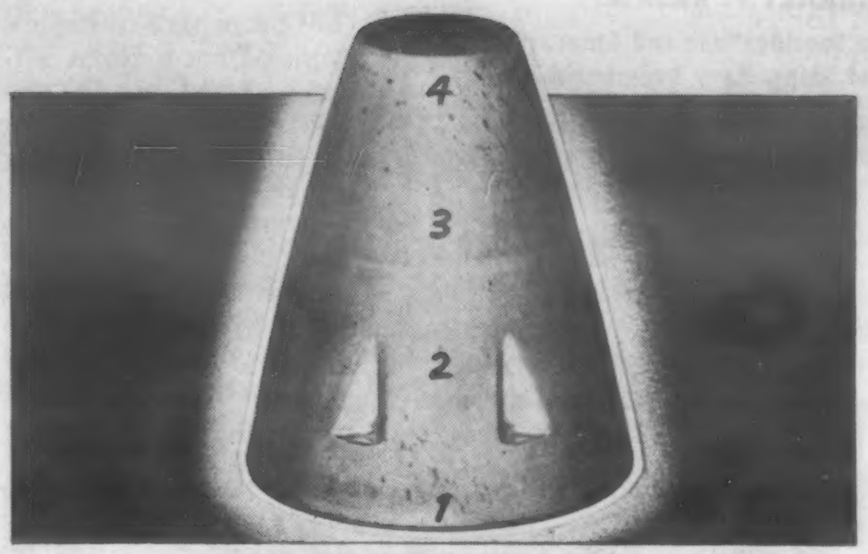
Class A.—Extra heavily coated sheets that are not intended to be formed other than by corrugating.

Class B.—Heavily coated sheets that are not intended to be formed other than by corrugating and curving to large radii.

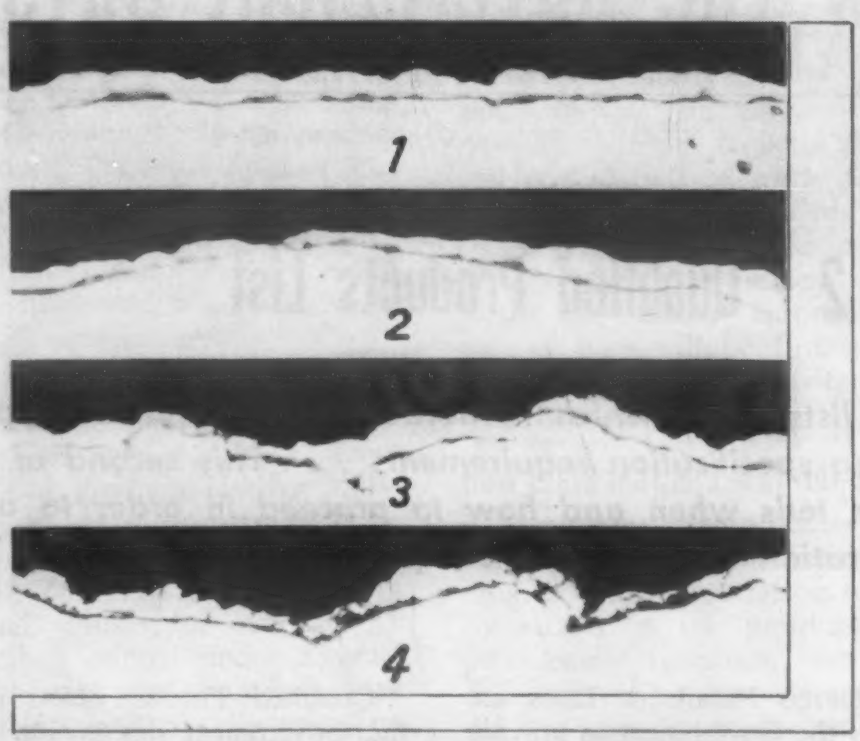
Class C.—Moderately heavily coated sheets for moderate bending.

Class D.—Ordinary coated sheets for general utility. These coatings approximate those of class C except in medium gages in which coatings of class D are appreciably lighter. Class D represents material generally available in warehouse stocks which is not intended for use where relatively long life, represented by classes A, B, and C, or severe forming, represented by class E, is required.

Class E.—Sheets having lighter, more tightly adherent coatings to reduce liability of flaking in severe forming.



Ogive deep drawn from sheet of Weirzin



ELECTROGALVANIZED COATING on this ogive demonstrates good adherence in drawing operations. At 1500 magnifications, draw marks appear as hills and valleys on surface.

it to take as severe a draw as the annealed base steel without failure of the protective coating. Previously, steel with heavy zinc coatings could be cold formed only to a limited extent before flaking or peeling of the coating occurred. Where severe deformation was required, thin coatings were applied and rust protection was sacrificed. If high resistance to corrosion was necessary, products were regalvanized after fabrication in order to provide thick coatings. The continuous galvanizing line makes it possible to produce deep drawn products having a high degree of corrosion resistance equal to that of the flat stock. Because of the uniformity of coating thickness, average die clearances for cold rolled stock are applicable.

The outstanding properties of the continuous line product have led to much broader application of galvanized sheets and strip. The proportion of steel used for furniture, appliances, containers and toys has increased steadily since the introduction of high speed continuous galvanizing. Developments in the heating, ventilating and refrigeration fields have also created a heavy demand for the improved product. Galvanized steel probably has the most flexible and versatile protective surface that can be applied to finished steel products. The outlook is one of ever widening application.

Electrogalvanized Steel

Electrodeposition or electrogalvanizing has made considerable progress in recent years. The electrolytic method does not affect the physical properties of the base steel and, therefore, can be used on the higher carbon grades of steel subjected to special heat treatments. The process gives a homogeneous and uniformly thick deposit of pure zinc having a smooth shiny surface. The zinc coating is tightly bonded to the steel base to provide excellent adherence and ductility. It does not peel, flake or powder in normal fabrication but remains intact and of even thickness. Electrogalvanized sheet is especially suitable for chemical treatments like bonderizing; the resulting product has a surface well adapted to enameling, lacquering, varnishing or lithographing. A particularly attractive metal finish is provided by job plating shops that have adopted "bright zinc" coatings.

Although electrogalvanized steel is competing with hot dipped to a limited degree, its widening market is in fields previously closed to galvanized steel. One application of considerable interest is its use for automobile mufflers. Despite doubts that zinc in any form could withstand the acid concentrate deposited in a muffler, electrogalvanized steel has stood up well in tests lasting over a year, and is now being used for this application to the extent of the material available.

Another interesting use is laminations for fractional horsepower motors. This application is growing because the electrogalvanized material appears to have better electric properties than the conventional laminated stock, and because of the improved die life resulting from its use. The coating actually lubricates the dies without leaving a zinc deposit. In one case a half million blanks were made from electrogalvanized steel without reworking the tools, whereas only 150,000 to 200,000 pieces were possible with the conventional material.

Annual production of electrogalvanized steel is more than 150,000 tons. This figure will probably increase as the desirable characteristics of the material continue to win recognition. However, the increase will not be at the expense of hot dipped galvanized steel, since cost favors the latter.

Photos Courtesy Armco Steel Corp. and Weirton Steel Corp.

by MARGARET P. HASKIN,
Purchase Specifications and Standards Branch,
Bureau of Ships, Navy Department

How The Government Buys

Part 2 · Qualified Products List

These lists show which manufacturers can furnish products meeting specification requirements . . . This second of three articles tells when and how to proceed in order to obtain qualification approval of your products.

● QUALIFIED PRODUCTS LISTS are issued by the Government to provide information on the ability of manufacturers to meet the requirements of Government specifications. They are issued *only* when the specification requires testing prior to award of contract. Such requirements are necessary where the unsatisfactory performance of the product may endanger the lives of personnel or where complicated designs and the nature of time consuming tests would unduly delay delivery of the product.

The fact that a product has been tested and included on a Qualified Products List is evidence *only* that a manufacturer can meet the specification requirements. Inclusion on a list does not relieve the manufacturer of his obligation to maintain such qaulity. The listing does not guarantee acceptance of the product in any future purchase nor does it constitute a waiver of the requirements of the specification as to acceptance, inspection, testing or other provisions of any contract.

Qualified Products Lists contain the Government designation of the product, the manufacturer's name and address, including the address of the plant from which the sample was submitted.

Lists are identified by the symbol "QPL" followed by the number of the associated specification and a number to identify the issue of the list. For example: QPL-3125-1 indicates that this is the initial issue of the list associated with Military Specification MIL-P-3125; and QPL-P-R-791-2 indicates that this is the second issue of the list associated with Federal Specification P-R-791.

Changes in a Qualified Products List are made by revision or amendment. A revision consists of a complete new list identified by a new suffix number in numerical sequence —thus the revision of QPL-3125-2 is QPL-3125-3. An amendment consists of an additional sheet or sheets containing only the changed listings, identified by date and amendment number placed below the existing symbol. For example:

QPL-18-5
Amendment—2
1 October 1948
SUPERSEDING
Amendment—1
16 September 1948

Amendments are cumulative and each successive amendment is written to supersede the previous one, completely.

When Qualification Is Required

If qualification testing is necessary, the following information will be contained in the specification covering the product:

1) Section 3 (requirements) of the specification will contain a requirement (usually par. 3.1) that the product furnished shall have been tested and passed the qualification tests; 2) Section 4 (Sampling, Inspection and Test Procedures) of the specification will state the tests to be made on the product; 3) Section 6 (notes) will contain a paragraph stating that the right is reserved to reject bids on products which have not been tested and found satisfactory for inclusion on the Federal or Military Qualified Products List, as applicable. This paragraph will also list the name and address of the activity responsible for qualification.

Qualified Products Lists are always open for inclusion of products from additional manufacturers which become qualified as a result of tests. They are not issued to restrict either bidding or awarding of contracts. All manufacturers have equal opportunities and are urged to communicate with the activity responsible for qualification and arrange for tests on the products they intend to offer.

How to Get Qualification Approval

Procedures have been established for Military Qualified Products Lists. At the present time there are no established procedures for Federal Qualified Products Lists. Most Military activities when responsible for qualification under a federal specification use the established Military Qualified Products List procedures. Since the Federal Qualified Products List policies are essentially the same as those governing the Military, it is expected that the procedures when issued will also be the same.

When a manufacturer desires to furnish a product covered by a speci-

fication requiring qualification approval, he should first review the specification and determine by actual tests whether his product falls within the performance or design limits. He should then contact the activity named in the specification which is responsible for qualification and request that his product be tested.

After qualification of a product is requested and approved, the activity responsible for qualification will authorize the test and send the manufacturer necessary information including the following:

1) A copy of the QPL Summary with a request for a certificate and statement from the manufacturer as required by it. (The QPL Summary is a leaflet covering the information to be furnished by the manufacturer and the rules that govern testing); 2) instructions for forwarding the samples; and 3) information on payment of costs of test.

After certification has been made by the manufacturer as required in the QPL Summary, tests will be conducted at the laboratory designated by the activity responsible for qualification. This activity will notify the manufacturer of the test results and whether the product has met the requirements of the specification. If the product meets these it will appear on the applicable products list.

How to Get an Extension

Qualification approval applies only to the product that is manufactured at the plant which produced the sample tested, unless an extension of approval is made by the activity responsible for qualification. Extension of approval to other plants of the manufacturer may be made when testing shows that the product is equal in all respects to the qualified product. Testing in these cases may vary from a few hours work to complete repetition of all the qualification tests. The laboratory which made the initial test is usually assigned the task of investigating the product from the other plant. This investigation is necessary because of varying conditions in plants due to labor conditions, production line techniques, inspection procedures, differences in raw materials, and in some cases, variations in laws from one state to another.

Products Manufactured by Others

A supplier, to be eligible for award of contract to furnish an approved product manufactured by another firm is required to state in his bid the name of the actual manufacturer, the manufacturer's designation for the product and the qualification test reference number. His bid will then receive the same consideration as bids for approved products from other sources.

A distributor or dealer who is completely responsible for the distribution of a product carrying his brand designation but manufactured by another company is eligible for listing on the Qualified Products List. In such cases the actual manufacturer is contacted to determine that the distributor or dealer is authorized to rebrand the product under his own designation. When such permission has been granted to the distributor or dealer, a sample of the rebranded product will be tested by the Government. If the product is approved, Qualified Product List will show the brand designation of the distributor or dealer; the name of his firm as distributor or dealer; and the name and plant address of the actual manufacturer.

Removal from a List

A product may be removed from a Qualified Products List for violation of any of the provisions upon which qualification approval was granted. The following are among the usual reasons for removal: a) the product offered under contract does not meet the requirements of the specification; b) the manufacturer is delivering a product different from that originally qualified; c) the manufacturer has discontinued manufacture of the product; or d) request for removal by the manufacturer.

Except where the manufacturer has requested removal of his product, the activity responsible for qualification will notify him of the proposed removal of the product from the Qualified Products List stating the reason for this action. The manufacturer will be invited to comment on the proposed action. Upon removal of a product, the activity responsible for qualification will notify the manufacturer by letter, and will delete the product from the list by means of a revision or amendment of the applicable list.

A product will also be removed from a list if it does not meet the requirements of a revised specification. In this case, the manufacturer will be given the opportunity to submit new samples for test to determine compliance with the revised requirements. If resubmission is made within the time specified by the activity responsible for qualification, removal action may be delayed until tests are completed.

Cost of Tests

The Government is not a testing activity for purely commercial interests from which it derives no benefit. Therefore charges for conducting qualification tests are based on the interest of the Government in each particular case. Qualification tests will be conducted without charge when the number of approvals issued is so small that adequate competition has not been developed in industry and when testing has not established sufficient sources of supply to assure availability of the product in the quantity required. In other instances cost of tests will be borne either by the manufacturer or divided between the Government and the manufacturer according to the best interests of the Government. Information on cost of tests will be furnished the manufacturer by the activity responsible for qualification.

How Lists May and May Not Be Used

Lists of qualified products are for the convenience of the Federal Government and its contractors and subcontractors in the performance of procurement functions. Each qualified products list carries a notice that the list may be made available to prospective bidders or suppliers who require it in furnishing supplies or service to the Government. It is the responsibility of Government Inspection offices to determine when the information contained in the Qualified Products List is required by either prime contractors or subcontractors, and to issue this information. Copies of the lists are not furnished to manufacturers, since the notification of approval to the manufacturer when his product is approved contains information necessary for his use in the preparation of bids.

The listing of a product, the letter of notification, results of tests, or other information relating to qualification shall not be reproduced, circulated, referred to, or otherwise used for publicity or advertising purposes, or for sales other than those leading to ultimate use of the product by an agency of the Federal Government. If so used, the listing is subject to cancellation.

Materials at Work

Here is materials engineering in action . . .

New materials in their intended uses . . .

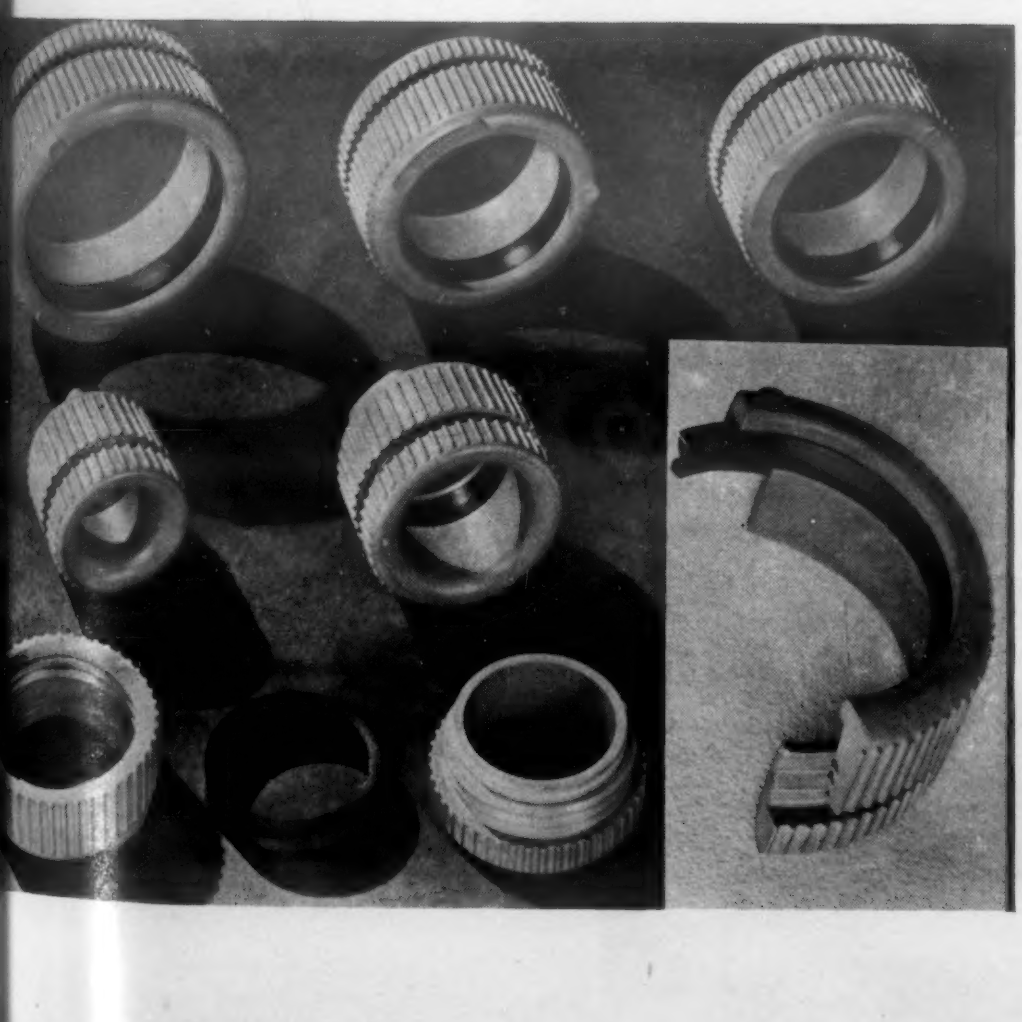
Older, basic materials in new applications . . .

High Conductivity Copper A forged and machined Oxygen Free High Conductivity Copper Ring is being tested here with a magnatester in the plant of the Philadelphia Bronze and Brass Corp.

Rings of this type are being used in squirrel cage type motors manufactured by G-E. This type of copper, guaranteed by the company to possess a minimum conductivity of 98% I.A.C.S., is used because the bus bars, extending from the center of the motor, must be brazed in slots milled in these rings.

Nickel That "Breathes" Porous metal sheet that looks solid, but allows smoke to go through easily is made by sintering pure nickel powder or the powder of prealloyed Monel or 18-8 stainless steel. It is strong and its chemical and physical characteristics parallel those of solid metals.

An outboard motor fuel line has been made of porous stainless steel. Two in. in dia, by 9 in. long, it was formed and welded by Micro Metallic Corp. to produce 0.35 sq ft of filter area. This design is used where structural strength is important and where lack of internal resistance to flow is a critical item. The sintered metal has been used to filter oxygen, fluorine, viscous plastics under high pressures, and in various chemical processes.

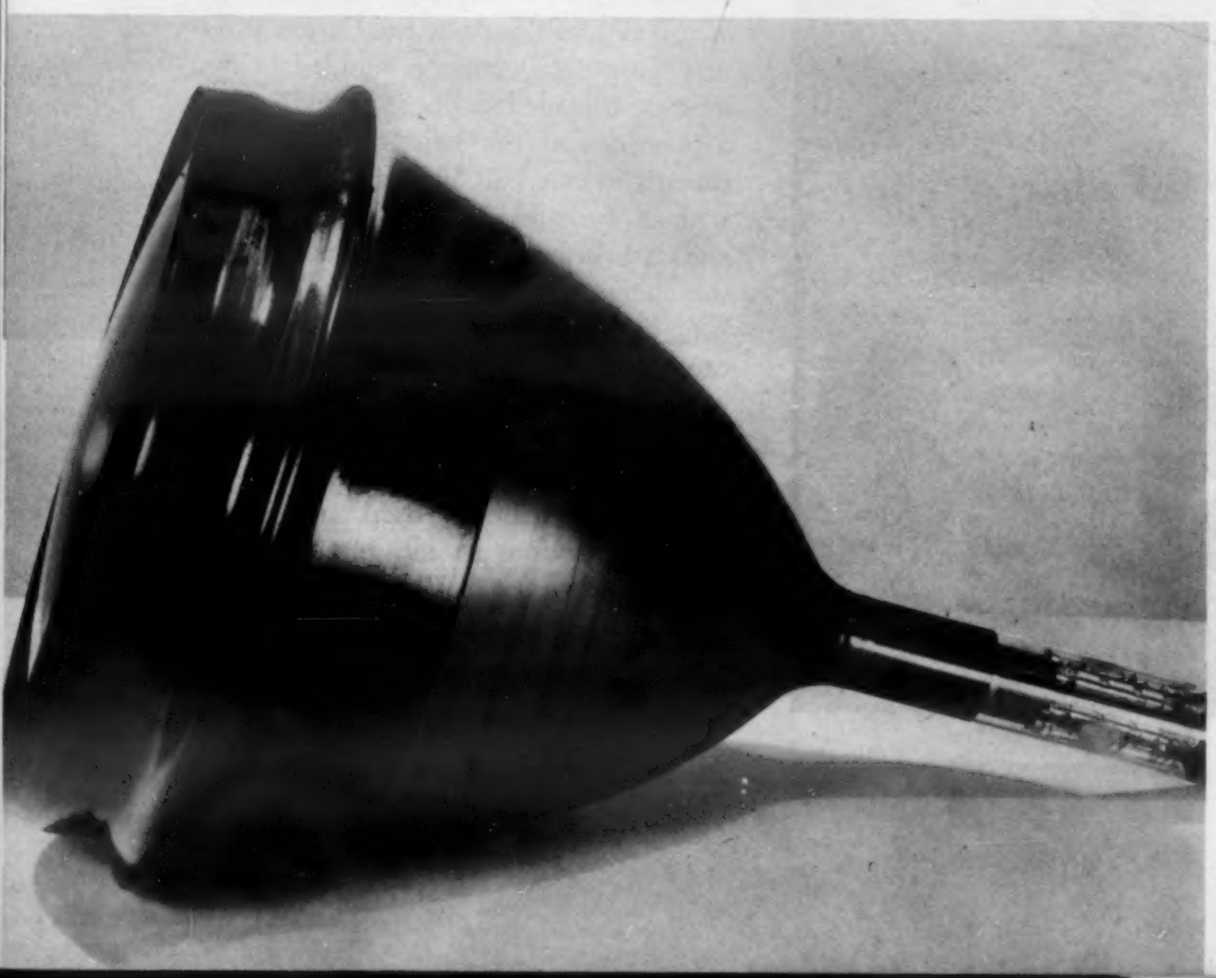


Plastic Clamp Connects Flexible Tubing These plastic clamps are said to effect a tight, permanent seal when flexible plastic pipe is connected by means of insert couplings, tees, ells and adapters. Developed by the Carlon Products Corp., the clamp is molded in two separate threaded sections. Butted against a shoulder at the base of the female threads in one half is a synthetic gasket with a v-shaped groove. When pipe ends are inserted and the other half of the clamp screwed down onto this gasket, it is forced in against the pipe, causing it to grip the insert fitting. Connections made in this way are stronger than the pipe itself.

The clamp is designed to replace the steel clamps formerly used, and is said to be impervious to rot, rust and electrolytic corrosion. When the unit is positioned, the gasket is completely enclosed by plastic, and is then protected from fluids, ozone and like factors.

Cast Monel Impeller This impeller, cast in "S" Monel by the International Nickel Co., will be used to pump 120,000 gal of sea water per min at a total discharge head of 10.5 ft. It was cast for a large chemical company to maintain proper circulation of water in condensers for the turbine generator in connection with the extraction of magnesium and other chemicals from sea water.

The alloy was selected to withstand the corrosive and abrasive attack of the water. According to the company, it is the largest impeller cast of "S" Monel in their foundry.

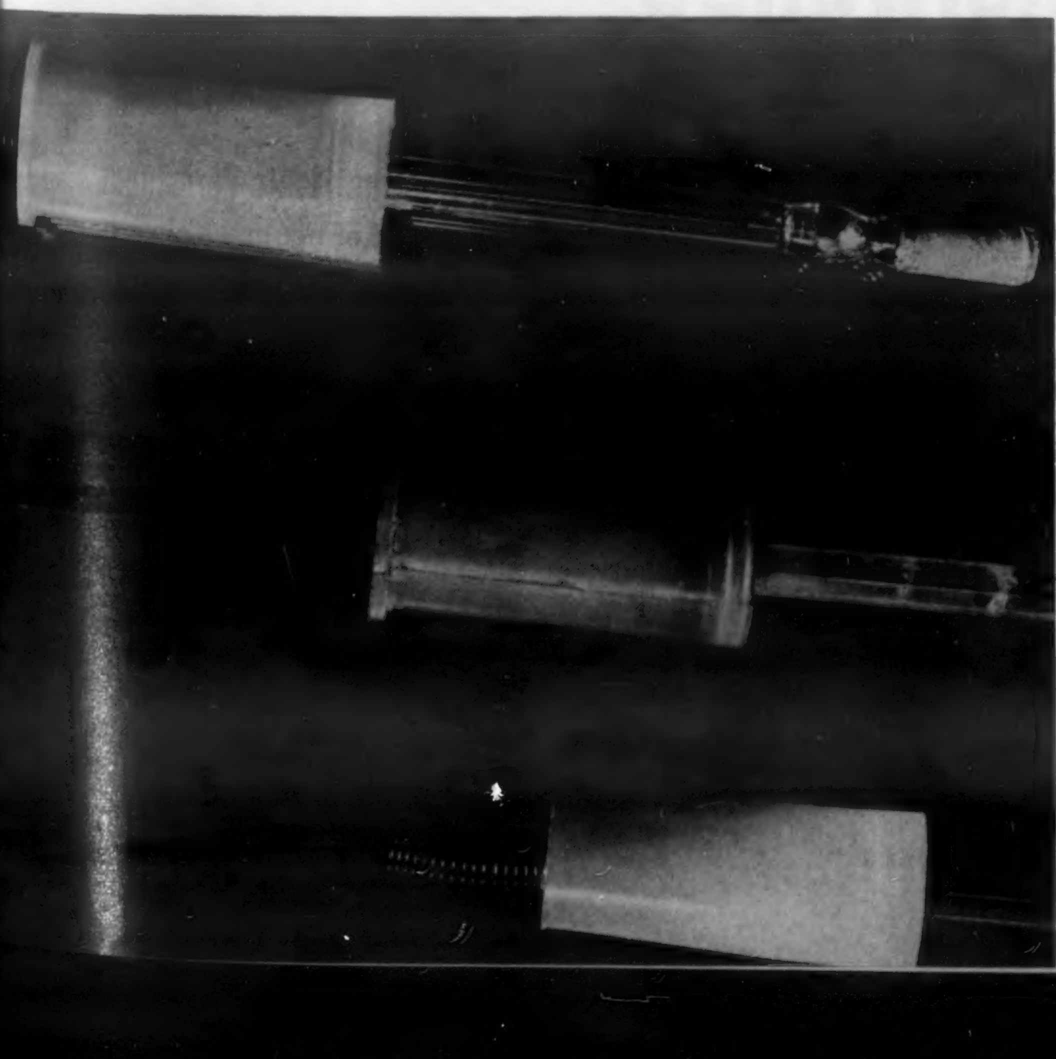


Plastic Insulator for TV Tube The excellent electrical qualities of polyethylene are utilized in the Anchor Weld Bead Insulator for this tri-color television tube. The ring is used to insulate the Ultor terminal, which is a metal flange running around the periphery of the otherwise all-glass tube. The voltage in the terminal is as high as 20,000 v.

The heavy construction of the insulator is said to provide ample protection against leakage, corona and shock.

Glass Protects Steel Tubing Glass, an excellent material for resisting the corrosive attacks of sulfuric acid in the lower temperature states of air heater tubes, is considered too fragile for power house use. However, when it is applied as a coating to carbon steel tubing, the resulting product combines the corrosion resistance of the glass with the strength of the steel.

A process utilizing special equipment evolved by the Barrows Porcelain Enamel Co. is said to simplify the unwieldly and expensive procedure of coating the steel tubing with glass both inside and out. As well as providing a corrosion resistant finish, the smooth surface of the glass deters clogging and simplifies the washing down of the tubing.



Nylon Improves Performance of Reference Electrodes Caps molded of Du Pont nylon are being used by the Leeds Northrup Co. to improve the performance of their industrial and laboratory pH measuring devices.

The strength, dimensional stability and good electrical qualities coupled with the resistance of the material to high temperatures and chemical attack are said to considerably lengthen the service life of flow-type and immersion-type electrodes. The electrodes are used in controllers for industrial measurements and pH indicators for laboratories.

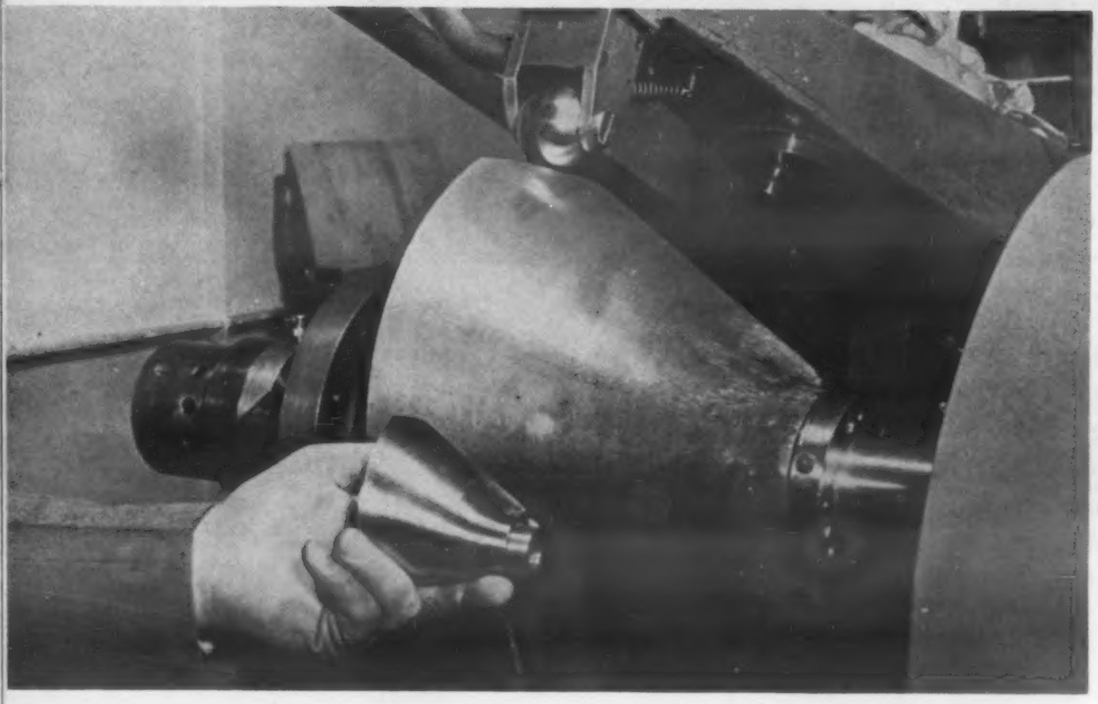
During company tests, the nylon capped electrodes were boiled steadily for 9 mo in solutions with pH's varying from 3 to 14 with no effect on the material other than a slight discoloration.

Glass Fiber Reinforced Drip Pan

The first glass fiber reinforced plastic drip pan is shown here installed in a refrigerator car of the New York Central System.

The present galvanized steel drip pans, which gather salt water draining from bunkers filled with ice and rock salt, have a useful service life between 6 and 7 years, while indications are that the plastic pans will last the life of the car, which is from 20 to 30 years.

Manufactured by Basson's Industries, the pans are also said to offer a weight saving of about 50 lbs each.



Quality Controlled Cast-Iron Used for 3-D Cams

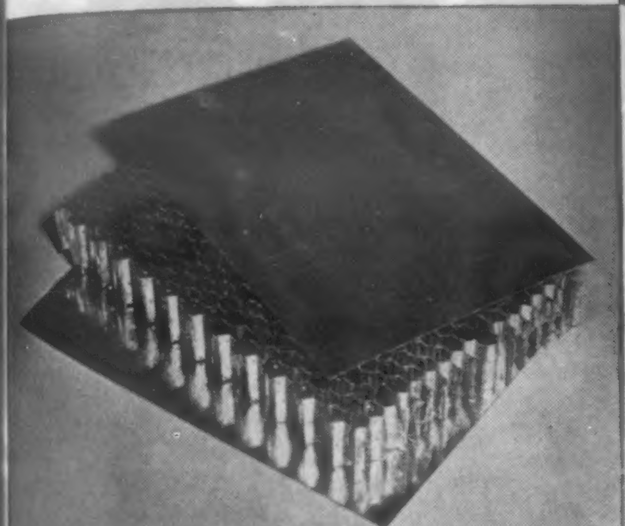
As many as 2000 data points are end-milled in order to set the contours of hand-cut masters for these Meehanite cams produced by the Ford Instrument Co. According to the company, Meehanite was chosen to meet the requirements for machinability, edge-strength and wear properties. After casting, the cams are heated to their sub-critical temperature for stress relief, then furnace cooled to minimize thermal stresses. Two shaping cuts are usually sufficient.

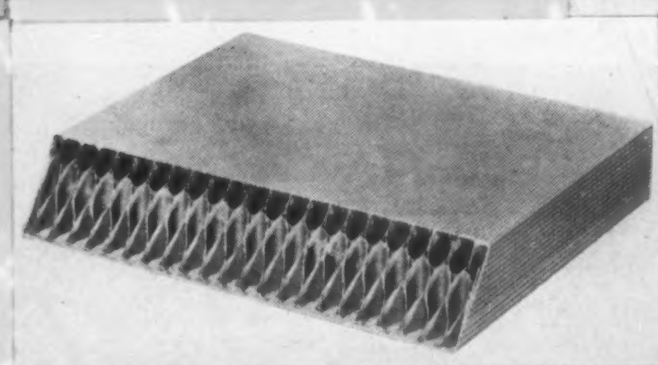
The cams are then rust-proofed by boiling in a 10% solution of ammonium hydroxide followed by a baking out process for 2 hr at 250 F. The final dimensions are held within ± 0.0005 in. tolerance, and the hand-polished finish possesses a 20-micro inch surface.

Cellular Rubber Gives Floats Permanent Buoyancy

A myriad of non-interconnecting cells is said to give permanent buoyancy to floats made of a rigid cellular rubber known as Spongex Cell-Tite, produced by the Sponge Rubber Products Co. First developed for carburetors using aircraft fuels, the floats are said to be gaining acceptance now for other applications.

According to the company, the buoyancy of the floats can be varied by changing the density, which can range from 5 to 20 lb per cu ft, with a compressive strength of 30 to 400 psi depending on the density.





Sandwich Materials

by KENNETH ROSE, Midwestern Editor, Materials & Methods

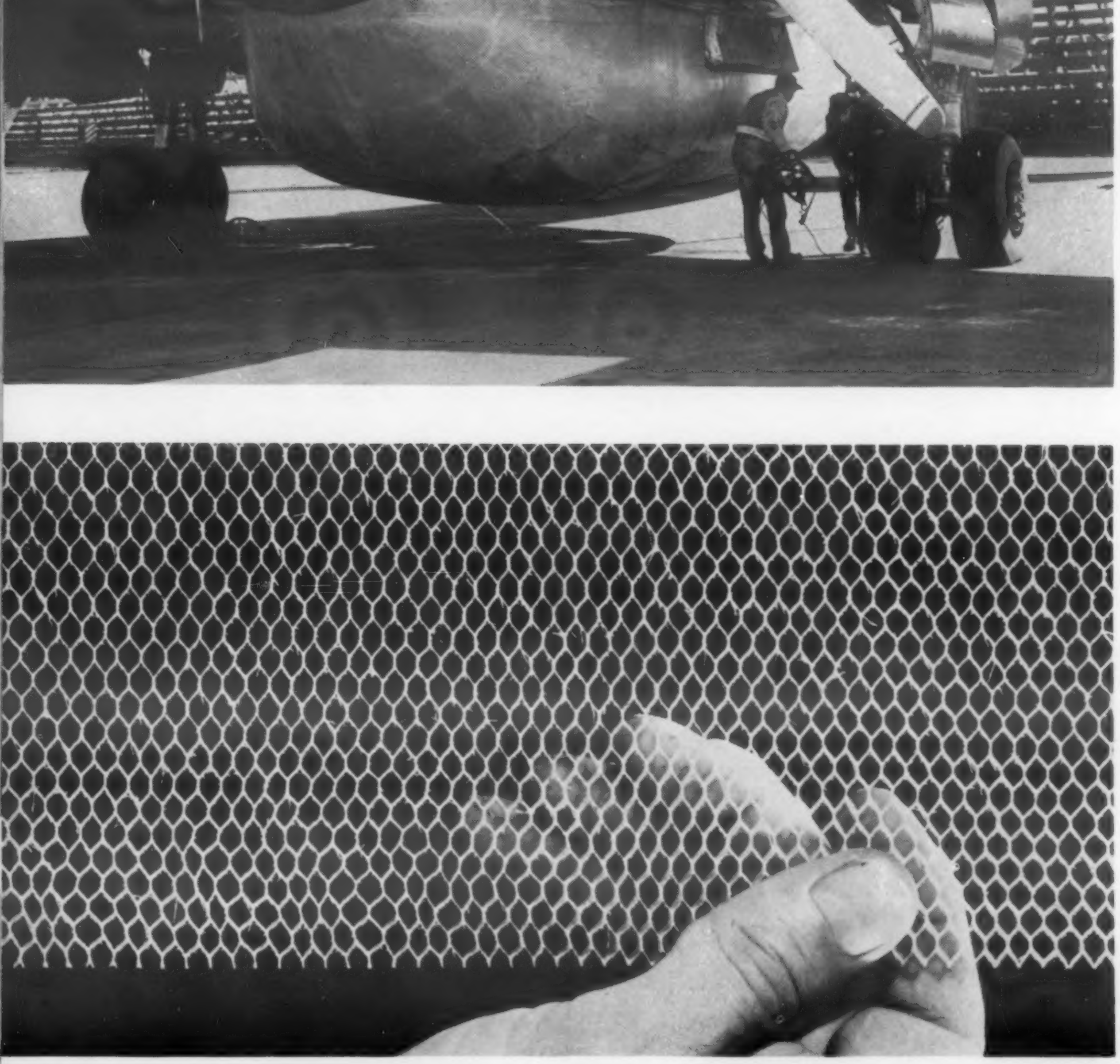
MATERIALS & METHODS
Manual No. 103

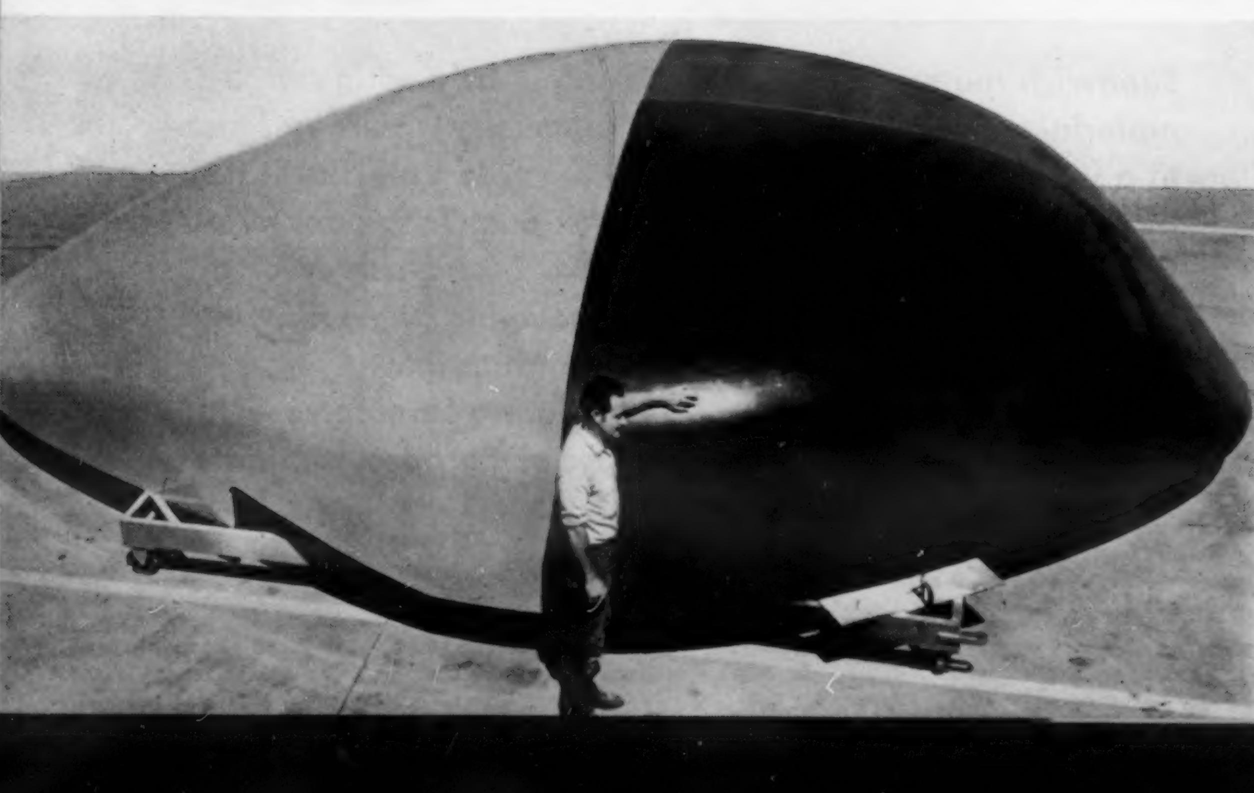
This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and applications.

MARCH 1954

Sandwich materials cover an extraordinarily wide range of material combinations. This great diversity naturally leads to a wide range of properties and possible uses. But it also makes the job of selection a complex one. To aid materials users, therefore, this manual gives a broad survey of the available sandwich materials by covering the following:

- ***Facing Materials***
- ***Structural Strength Laminates***
- ***Core Materials***
- ***Insulating Laminates***
- ***Special Purpose Laminates***





● COMPOSITE MATERIALS include such widely divergent compositions as laminated metals, in which two or more layers of metal are joined intimately; plywoods, and especially the plywoods in which unlike woods are laminated together; linoleum and similar compositions, in which a surfacing of oxidized linseed oil, plastics, etc., is laminated to a base of coarse fabric or heavy felt or paper; a wide range of laminated films and fabrics, including backed fabrics, plastics coated fabrics, fabric-backed rubber, and wire-reinforced rubber and plastics; and special constructions involving dead-air space. Of these composites, there is a smaller group, widely divergent within itself, that has been called *sandwich construction,* or *sandwich materials.* This manual will be concerned only with this group of composite materials.

The wide range of materials and construction used in sandwich materials is indicated by the difficulty in formulating a good definition; it is impossible to give a simple statement or description that will cover all the types involved and also exclude the compositions not to be covered.

The sandwich materials are defined by one of the largest producers as laminates consisting of three plies—two faces and a core. However, this simple statement of three-ply construction is inadequate, as it would include many materials properly considered as plywoods, and others more accurately classified as clad metals. Adding the idea of laminates bonded by an adhesive would exclude the clad metals, but would also exclude certain formed-in-place construction that is true sandwich type. Qualifying the definition by stipulating that the core material be dissimilar from the face material would eliminate the plywoods having three plies of the same material, but would also eliminate the sandwiches having aluminum faces and aluminum honeycomb cores. The most satisfactory definition, then, would seem to be: *A*

Both randomes of this Super Constellation are fabricated of sandwich material which uses a glass fabric-plastic honeycomb core (center). The belly radome is probably the largest reinforced plastics structure ever built.

sandwich material is a three-ply laminate, bonded by an adhesive or by natural adhesion, in which the core material is different in composition or in structure from the facing material.

This great diversity makes any complete listing of sandwich materials impossible. Almost any solid material, in almost any practical range of forms, sizes, finishes, etc., could conceivably be used for either facing material or core, so the number of combinations possible would be enormous. Many are in use, or have been tried. A relatively simple classification is possible by concentrating upon a few compositions typical of various constructions in actual use. Based upon type of use, the laminates may be combined into three groups:

1. *Laminates Designed for High Structural Strength.* In general, these include all the sandwiches having low density cores. The honeycombs, the metal-faced woods, and the foamed plastics laminates are typical. The faces are the load-bearing members, and the core serves to separate them so as to obtain a high section modulus, as in an I-beam.

2. *Laminates Serving as Insulators.* The sandwich may be used to reduce the transmission of sound, or heat, or electricity, or to damp out vibration, or for fire resistance. Thermal insulators usually make use of dead-air, whether the air is trapped in loose fibrous masses or in cellular structures. Flexible materials are used as vibration deadeners. Nonmetallic inorganics are used for fire resistance, or for electrical insulation.

3. *Miscellaneous Special Purpose Laminates.* Certain laminates are produced for special purposes, such as writability, or sealing. These follow no rules except to provide the special utility desired.

Sandwich materials are not new. They have evolved from plywoods, many of which are true sandwich materials. A veneered plywood, for example, having both faces of an expensive or figured wood and a core of a cheaper wood, is a sandwich material. This has developed along two lines—the facing materials have advanced from wood veneers to fiberboard, printed paper, sheets of plastics, aluminum, steel, copper, stainless steel, etc., and the list of core materials has lengthened to include lightweight woods, reconstituted woods, various types of special-purpose materials, and expanded or porous materials of many kinds. Corrugated board, a true sandwich material of many years standing, has faces of paperboard and a core of the same material in corrugated form.

In all cases, the laminates are bonded by an adhesive or by the natural adhesion of the core material to the facing. It follows that the greatest advancement in sandwich materials, has paralleled the great development in adhesives during the past several decades. This has made possible the laminating of metals and nonmetals in strong composites. About the same time, the expansion in the aircraft industry created a need for lightweight, high strength construction, with a premium price for materials that would meet high standards. For those sandwich materials that are designed for unusual stiffness at light weight, and are therefore rather high in cost, the aircraft industry is still one of the most important customers.

Sandwich materials are produced for many purposes. Many of them offer possibilities that can be converted into several different advantages, such as greater stiffness in a panel that can be utilized in weight reduction for the same stiffness as that in a prior design, or greater stiffness at the same weight. The more important advantages are:

1. Weight reduction.
2. Cost reduction.
3. Simplified construction.
4. Greater strength or stiffness.
5. Thermal insulation.
6. Fire resistance.
7. Moisture or water resistance.
8. Vibration or sound deadening.
9. Overcoming of size limitations.
10. Other special features such as writability.

A development of the past decade that has greatly broadened the field of application for sandwich materials is the use of dead-air cores that can be produced in place. These were German wartime developments, but they have been expanded in types and in fields of application in American technology. The biggest advantage that these produced-in-place

Typical Types of Sandwich Materials

Materials Used	Special Features of Laminate	Typical Uses
Laminated Woods	Lowered cost, light weight, increased strength or stiffness.	Veneered woods, aircraft parts, drawers and panels.
Metal-Faced Wood Core	Weather resistance, light weight, dimensional stability, increased strength.	Railway car partitions and bulkheads, table tops, truck panels, refrigerator panels.
Metal-Faced Plastics Core	Resilience, increased strength, electrical properties.	Gaskets, electrical circuits.
Plastic-Faced Wood Core	Moisture resistance, improved surface finish, dimensional stability.	Table tops, kitchen panels.
Wood-Faced Inorganics Core	Thermal insulation, fire resistance.	Flame-resistant doors and panels.
Metal-Faced Inorganics	Electrical properties, fire resistance.	Electrical circuits, flame-resistant pieces.
Paper-Faced Plywood	Increased strength or stiffness.	Containers, paneling.
Paper-Faced Dead Air Core	Vibration deadening, shock absorption, increased rigidity, weight reduction.	Packing and shipping containers, lightweight panels.
Metal-Faced Dead Air Core	Increased strength and stiffness, simplified construction, cost reduction, weight reduction.	Aircraft parts, truck panels, doors, decorative panelling table tops.
Glass-Faced Dead-Air Core	Low-cost laminate, transmits diffused light.	Doors, table tops, panelling.

cores have to offer in sandwich materials is in simplified construction. A structure may be formed as a shell, and the core material may then be added and expanded inside the shell to form a true sandwich construction. The shell need not be in the form of parallel sheets—in fact, it seldom is. The result has been to broaden the possibilities of sandwich construction to fields in which heretofore it might have been recognized as theoretically desirable but was impractical to adopt them for technical reasons.

Facing Materials

Plastic-faced plywood has many industrial uses. Top, it is being used in a foundry mounting plate; bottom, it serves as the surface of an assembly line table at Johnson & Johnson.

Practically any sheet material can be used as a facing material. It is important that the same material, or materials of approximately equal co-efficients of thermal expansion, be used for the two faces, as otherwise the laminate may warp with temperature change.

Woods—Any wood may be used, but the cabinet woods, possessing beauty of color and figure, are most popular. The facings may themselves be laminated stock. Mahogany, walnut, lauan and other woods sometimes referred to as "Philippine mahogany", the oaks, maples, and gums are most used for decorative facings and fir pine and spruce for utility facings. Facings may be used in any thickness from thin veneer stock to plywoods of medium thickness and in any finish.

Paper and Fiberboard—Heavy kraft paper is commonly used. Paperboard or fiberboard may be used to obtain greater thickness and strength. The facing may be calendered to a smooth finish or left in the rough. Smooth-surfaced papers may be printed to resemble wood grain in color and figure, and then impregnated with a phenolic resin and cured to produce an attractive woodlike surface. The facings may be sandwiches in themselves when a corrugated board is used over the core material. When the paper is impregnated with resin and cured, a hard, abrasion-resistant, moisture-resistant surface is produced.

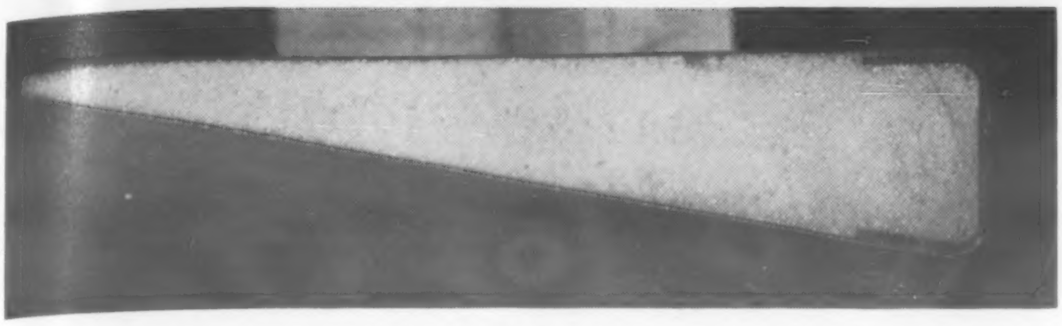
Plastics—Plastics are most commonly used as laminates, with paper, cotton duck, or glass fabric as the fibrous constituent. The phenolics are most used, because of the favorable price differential, but melamines and ureas are also laminated. Other thermosets, the resorcinols, alkyds, etc., are quite suitable for laminating into sandwich materials, but in general will have little to offer to offset their higher price. Plastics laminates are available in a range of thicknesses, colors, patterns, and rein-

forcements. Sandwiches are sometimes made with a composite of a plastics and some other material, as in the surfacing for cigarette-proof table tops, for which a sheet of aluminum foil is used under the plastics to conduct heat and hold temperature below the charring point.

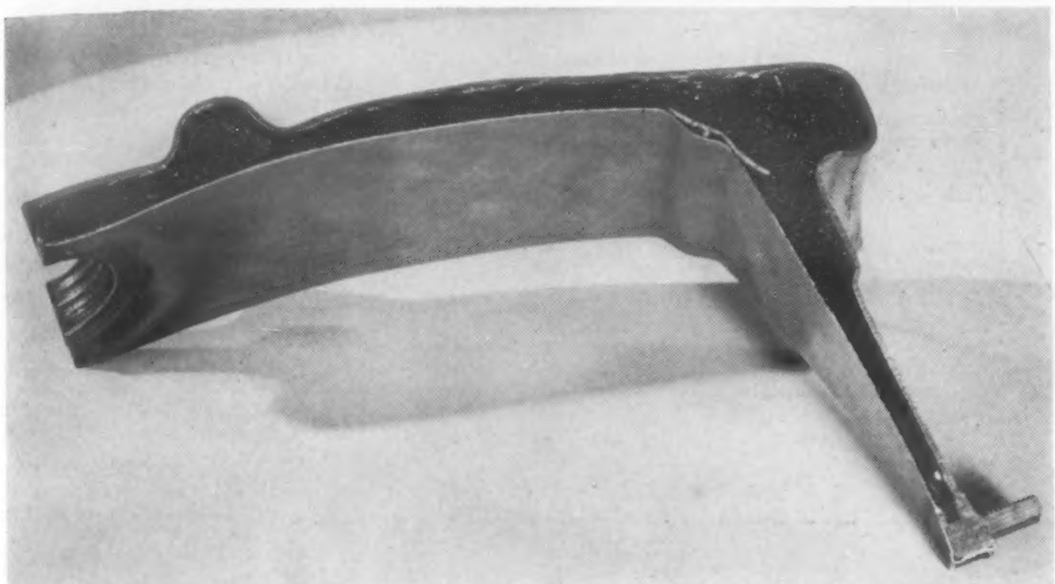
Metals—Sheet steel, zinc-coated steel, terne plate, aluminum and its alloys, copper, stainless steel, and magnesium alloys are facing materials for sandwich construction. Gages run from heavy foil to 1/8-in. and heavier. Finishes include all the standard finishes in all metals. Porcelain enameled steel is used as a facing for at least one sandwich material.

The embossed surface known as "rigidized", in which a pattern of small arches is pressed into the sheet to increase its stiffness, is used in sandwich materials. Sheet stock in both plain steel and stainless steel, with rigidized surface, is made into sandwich materials as standard types.

Nonmetallic Inorganics—These include asbestos-cement board and reinforced concrete. The former is a standard wallboard, while the latter is a standard building material.



End view of a sheet metal airfoil in which a foaming plastic was used as a reinforcing filler material.



A cross section cut from a beer barrel. Outer and inner skins are aluminum. Insulating core is a foamable resin foamed in place.

Core Materials

The range of materials used for cores in sandwich construction is much more diverse than those for facings. New materials, developed or adapted during the past decade, have been responsible for many of the advancements in sandwich materials. A description of the most important of these core materials follows:

Woods—Balsa wood, with a specific gravity of about 0.2, the lightest of the commercial woods, is a logical selection for low-density cores. It was one of the first of the low-density core materials used, forming the middle lamination in the wooden Mosquito bombers of World War II. While its open structure precludes the possibility of high strength, it has ample resistance to crushing when used as a core material.

Other low-cost woods, less expensive than balsa, have been used for many years as core materials in plywoods having true sandwich construction. Chestnut, cottonwood, basswood and yellow poplar are some of the most widely used core woods. These woods are generally soft, light, and weak, and of little value for outside veneers or for cabinetry.

Fiber blocks, in which the wood fiber is used as loosely compacted blocks of uniform size, make a low-cost low density core material. A reconstituted wood board, made by chipping blocks of wood and pressing the chips into a board with the aid of a resinous binder, is another low-cost core stock. Corkboard is a specialty material with good thermal insulation, and good resiliency. The insulating board made of bagasse fiber (sugar cane waste) is another fibrous core material. One of the most widely used core materials is plywood. It is on the market in a wide variety of woods as well as number of plies, type of bonding and overall thicknesses.

Paper—The long time use of paperboard, corrugated in a corrugating machine and glued to paper faces to form the well-known container board, has been mentioned as an early type of sandwich material. A wartime development was the paper honeycomb core. This is produced by impregnating heavy paper with about 10 to 20% of phenolic resin in the uncured stage, assembling the sheets into packs having regularly spaced glue strips on the surface of each sheet, placing the pack under heat and pressure to cure the bonds, and cutting the pack into slices which are then expanded to form the honeycomb. A honeycomb produced commercially has a hexagonal cell structure, the spacing and width of the glue strips determining the cell size. Cell sizes now in use are 3/4 in. and 7/16 in., measured across the flats of the cell.

The core stock weighs 2.2 lb per cu ft. Where increased wet strength or increased resistance to moisture pick-up is required, the content of phenolic resin may be increased to 18 to 20%. The resin is cured with hot air while the core is expanded, thus fixing the shape of the cells. A special radar grade of honeycomb has a 1/4-in. cell size. Other cell forms, such as figure-eight and corrugated, are also available commercially.

Cotton Fabric—Cotton fabric, impregnated with phenolic resin to the extent of 45% of the weight of the finished core, makes up into a honeycomb core useful where repeated impact loading is a service condition, or where thermal insulation is desirable. The cotton honeycomb is made in a light weight, weighing 4.7 lb per cu ft, and a heavier weight material of 8.6 lb per cu ft. The cellular structure is formed by curing the impregnated sheet while forming on a corrugating machine, cutting the corrugated sheet to length, indexing and assembling into a block, cutting slices from this block on a band saw, and edge gluing the slices to form the core blanket.

Foamed Plastics and Rubber—One of the most important advances in core materials is the use of foamed resinous materials. Some of these are thermoplastics, others are thermosets, still others are hard vulcanizates of natural or synthetic rubber. All have the same feature—a cellular structure produced by release of a gas while the plastics material is in a formable state. In the case of some of the compositions, the release of the gas and cure of the resin can be made to take place simultaneously, so that the cellular structure can be developed as the core material fills a cavity. This process of forming a core inside a cavity already created is of enormous value to the aircraft industry especially. Principal expanded plastics of interest here are given in the accompanying table.

Two foamed-in-place polyester resins are now available on an experimental basis to the Armed Forces, under designations Laminac 4231 and Laminac 4232. They are thermosetting materials usable to about 375 to 400 F, and sold at about $3 per lb. A very lightweight phenolic foam capable of foaming in place, such as inside a honeycomb structure to provide additional strength, is also being produced.

One of the most successful of the foamed-in-place resins is the di-isocyanate type, developed in Germany and imported into this country after the war. It has the considerable advantages of being exothermic, so that no outside heat is required to cure the resin, and of liberating its own foaming gas. It cross-bonds to produce a thermoset, usable to about 250 F for short time exposure. At a cost of $2 per lb in quantity it is too expensive for general use.

In the case of the phenolics, the foam is created by incorporating a gassing agent into the mixture of uncured resin and catalyst, or by whipping air into the mixture. The cellular structure is formed in the phenolic as it cures, and, as the entire slurry can be applied to the structure of which it is to form the core, the core can be formed in place.

Foamed silicone is still too new to evaluate its possibilities as a sandwich core material. At present, the foam is preformed. Temperature resistance of the foam itself is good at about 550 F, and if adhesives with comparable properties could be used for bonding, a laminate with excellent temperature resistance could be produced.

Another expanded material offered under the trade name Strux is made of cellulose acetate. The block of foamed plastics is sawed or sculptured to the form required for its use as a core material. Foamed polystyrene, called Styrofoam, is preformed in the same manner and is an excellent low temperature heat insulator.

Natural and synthetic rubbers can be foamed and vulcanized simultaneously by adding a gassing agent and a vulcanizing agent to the rubber or its latex, and heating. This operation

Principal Expanded Plastics

Trade name	Producer	Chemical type	Thermoset	Formed in place
Strux	Strux Corp.	Cellulose acetate	no	no
Lockfoam	Lockheed Aircraft Nopco Chemical Co. American Latex Products	Di-isocyanate	yes	yes
G-E Phenolic Foam	General Electric Co.	Phenolic	yes	yes
Insulfoam	Westinghouse Elect. Corp.	Phenolic	yes	no
Styrofoam	Dow Chemical Co.	Styrene	no	yes
Armofoam	Armour and Co.	Di-isocyanate	yes	yes
Flotofoam	Colton Chemical Co.	Urea	yes	—
Foamed Silicone	Dow Corning Corp.	Silicone	no	—
Foamed natural and synthetic rubber vulcanizates			no	yes

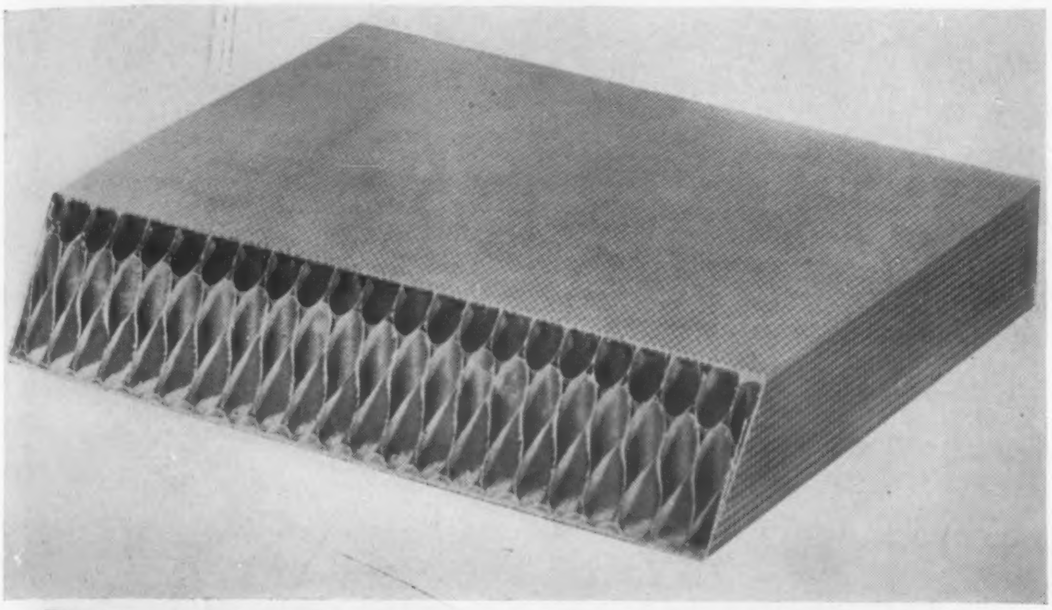
Physical Properties of Some Nonmetallic Cores

Material	Cell Pitch Across Corrugat., In.	Weight, Lb. Per Cu Ft	Crushing Str, psi	Shear Str, Long. Dir., psi	Modulus of Rigidity, Long. Dir., psi
4 oz impreg. cotton fabric	0.440	4.35	380	150	8,000
8 oz impreg. cotton duck	0.449	8.00	1000	340	17,500
70 lb impreg. paper	0.437	2.18	140	85	9,000

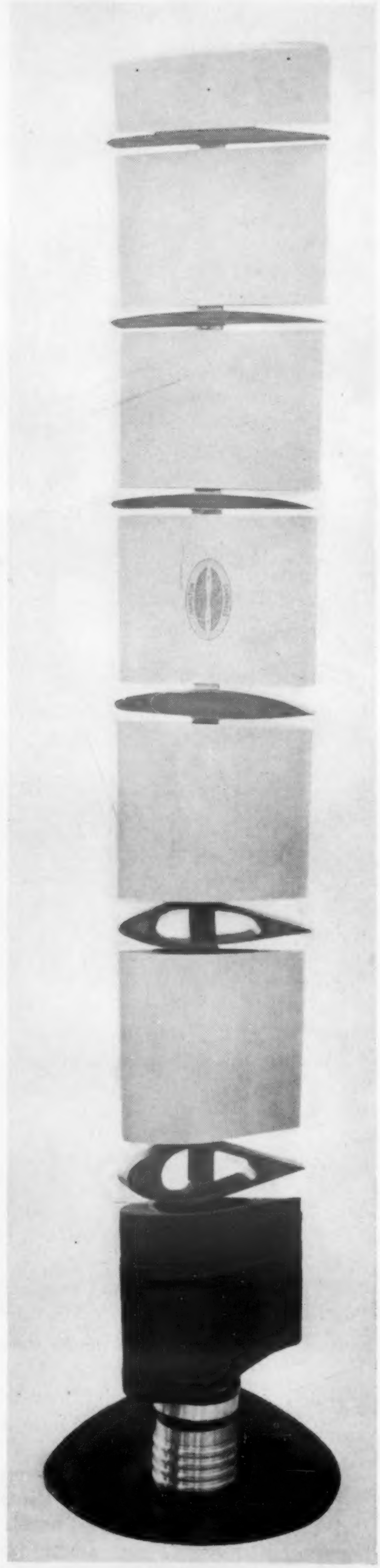
can be done in a metallic cavity to form the core in place. An unusual core material with good thermal insulation qualities is made with wood fibers expanded but held in semirigid form by a foamed resin. The foamed resin also confers moisture resistance and a degree of fire resistance upon the cellulosic fibers.

The fluorocarbon-plastics, including Teflon and Kel-F and the phenolic-hardened synthetic rubbers and vinyls, having a degree of natural resilience, make excellent core materials for gaskets and similar sealing applications.

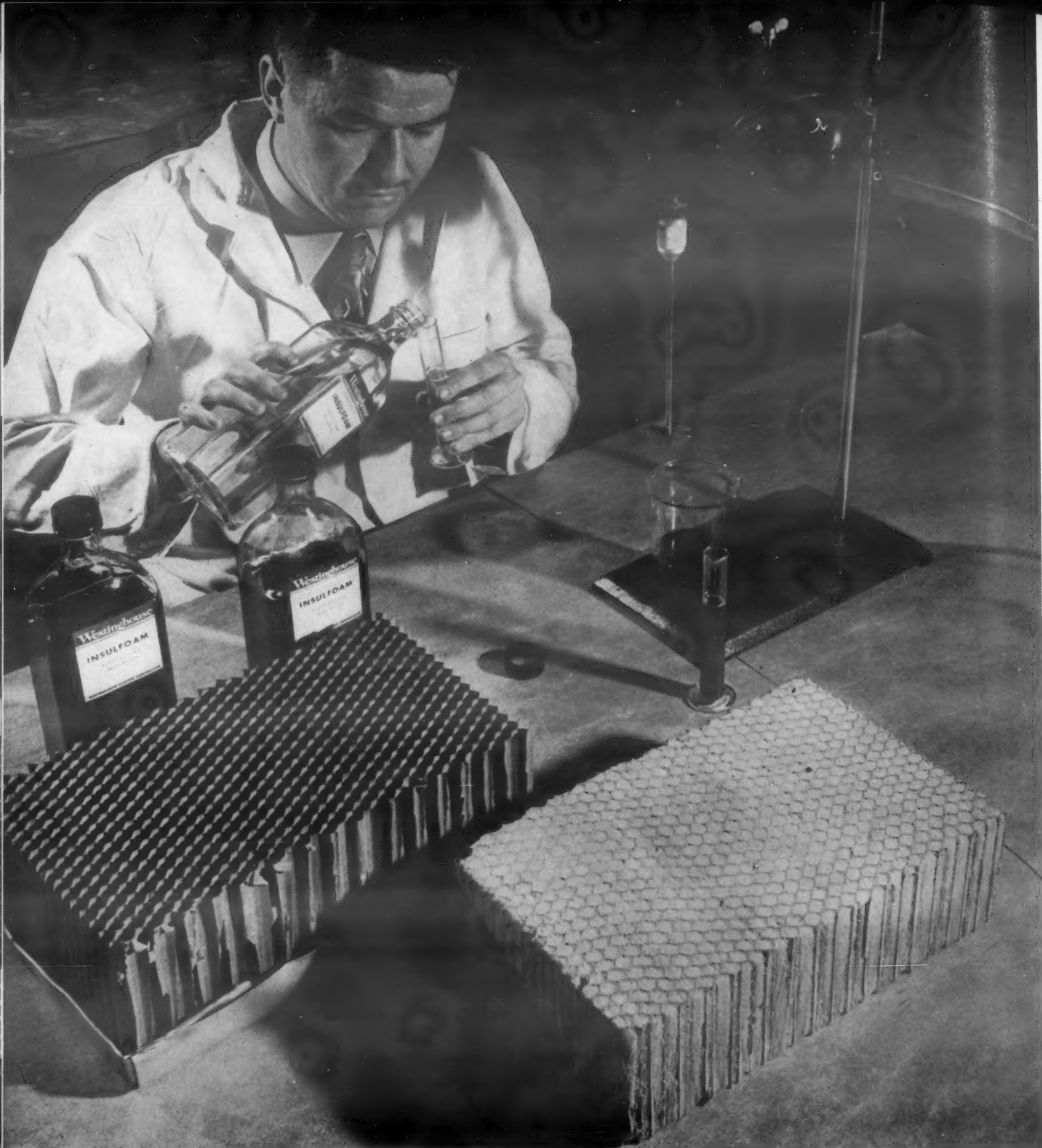
Metals—Metals are frequently laminated with wood, and occasionally with plastics and other organic materials, and they are sometimes used alone as cores in true sandwich construction. The best known and most successful of such metallic cores is the aluminum foil honeycomb. Aluminum foil is particularly suited to core construction because it is readily available, reasonable in cost, has excellent physical properties, is high-



This figure-eight paper core material is faced with embossed aluminum. Photo at bottom shows lightness of such sandwich panels.



Hollow steel aircraft propellers are reinforced with a foamed-in-place filler consisting of an acrylonitrile synthetic rubber and nylon.



Paper honeycomb sandwiches can be strengthened by foaming a phenolic in the air spaces.

ly resistant to corrosion, high humidity, temperature changes, and fungus growth.

The core is made by corrugating chemically clean aluminum foil strips and adhesive bonding them into a honeycomb block. The aluminum alloy used is 3S. Some experimental work has been done with 52S alloy, but the 3S composition has firmly established itself.

Core sizes are usually 1/4 in. or 3/8 in. The lightest-weight core uses 0.002-in. foil, and weighs about 2.9 lb per cu ft, and about the heaviest used to date is made with 0.006-in. foil and weighs about 11.0 lb per cu ft. The core can be cut accurately on a bandsaw, to within about 0.004 in.; for greater accuracy, the core can be rolled or pressed to the desired thickness within 0.002 in.

The core can be preformed for molding curved or formed panels. Simple curves can be rolled; more complex ones contoured from blocks or shaped between dies. The core can be perforated, easing escape of solvent gases from adhesive, and letting evacuating air through core to get atmospheric pressure on the outside faces when bonding.

Nonmetallic Inorganics—These are usually used for thermal insulation or fire resistance. Glass, used as the lightweight foamed material or as

glass fibers, is the best known. The glass fibers can be impregnated with a thermosetting resin and corrugated into a core material, or the corrugated sheet can be formed into a honeycomb. The glass cores are of special interest to the construction field because of their excellent resistance to moisture and weathering and their fire resistance. The laminates, made with glass fabric impregnated with a resin, usually a phenolic, are used industrially as core materials.

Another nonmetallic inorganic material that is a standard core material is the complex calcium magnesium silicate sold under the trade name Kaylo. This is an excellent thermal insulator, and it is so used in sandwich construction. No attempt is made to obtain any structural lightening of the core, by means of foaming or other device to produce dead-air spaces. Solid sheets are used in thicknesses of about 1 in. to 1 1/2 in.

Exploded concrete, exfoliated mica, rock wool, and similar materials are used as cores, especially when produced as blocks or aggregates. Their biggest use is in construction.

Structural Strength Laminates

In sandwich materials designed for high structural strength, a core separates the two faces so that the bending moment of the entire laminate will be reflected in shear on the face. For short spans or for local stresses, the shear strength of the core may be critical, but in longer spans, flexural failure usually results from the buckling of that face which is in compression. In a properly designed panel this failing stress should exceed the yield strength of the face. Crushing strength of the core is sometimes critical in the area where the panel passes over supports, especially when the panel is heavily loaded.

Honeycomb panels are excellent for carrying shear stresses in the plane of the panel. Here the core stabilizes the faces, preventing their wrinkling and failing until the full shear strength of the material is exceeded.

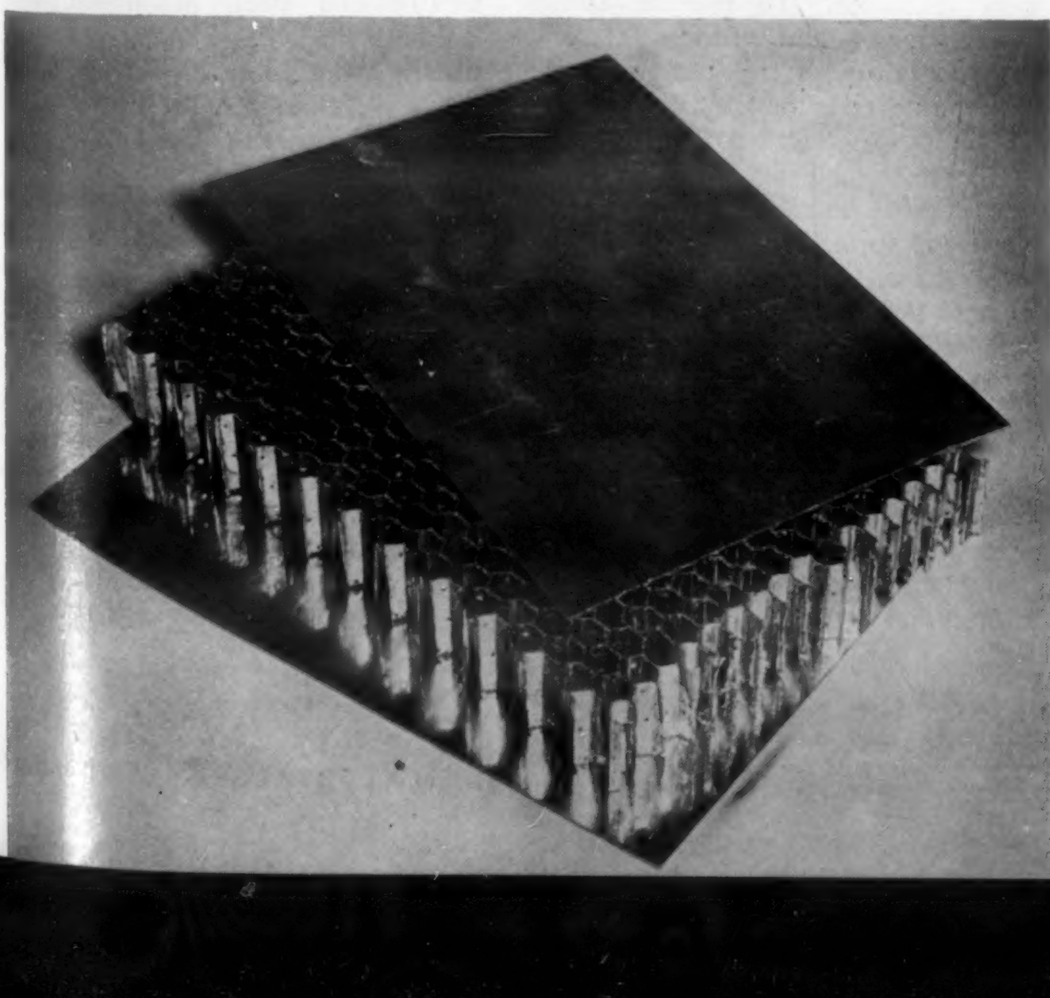
Laterally loaded plates may fail: 1) due to shear failure in the core, 2) through compression failure in the core, or 3) by tension or compression failure in the faces.

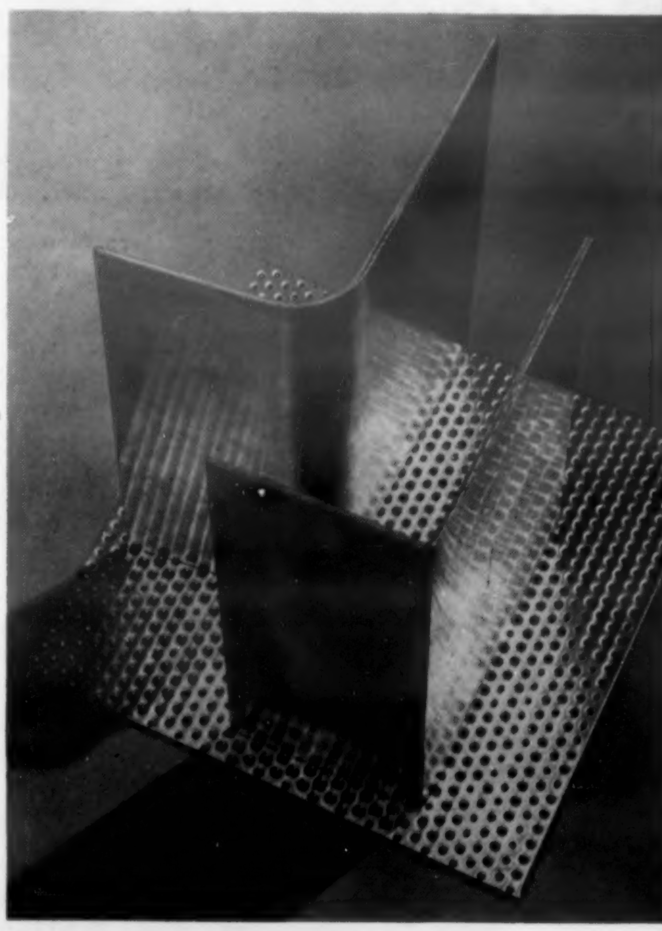
These high-strength laminates cut across all composition types. The earliest were plywoods in which the core consisted of a low-cost, lightweight wood. In these types the primary purpose of the lamination was to lower the cost of the composite, but the idea of achieving lighter weight by using lighter core stock soon was recognized. Metal-faced plywood, in which sheet metal was bonded to a plywood core, was developed before the war. As the value of lightness combined with strength was emphasized by the aircraft industry, along with a willingness to pay a substantial premium for substantial weight saving, the core became the critical part of the sandwich.

Balsa wood, with a specific gravity of 0.2, became the first really low-density core material to find wide use. Corrugated paper had already been worked into corrugated board, but with the new adhesives, honeycomb cores became effective laminates in structural sandwich materials. Foamed plastics and foamed rubber vulcanizates also found a place as core materials.

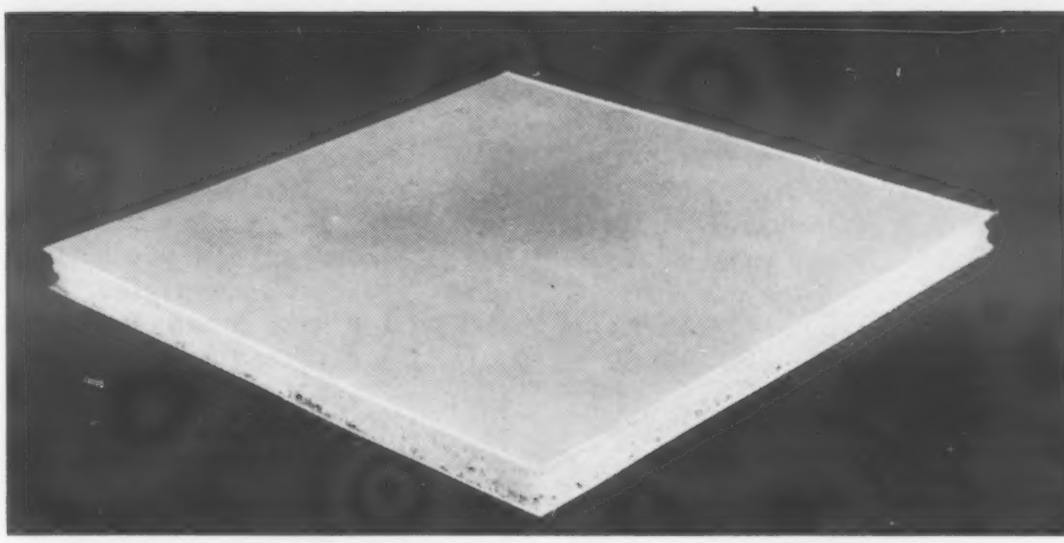
The fact that these dead-air cored laminates are often good thermal insulators increases their usefulness. Some are used in applications where their thermal insulation is a desirable additional feature, and others are

This type aluminum honeycomb finds use in many aircraft assemblies.

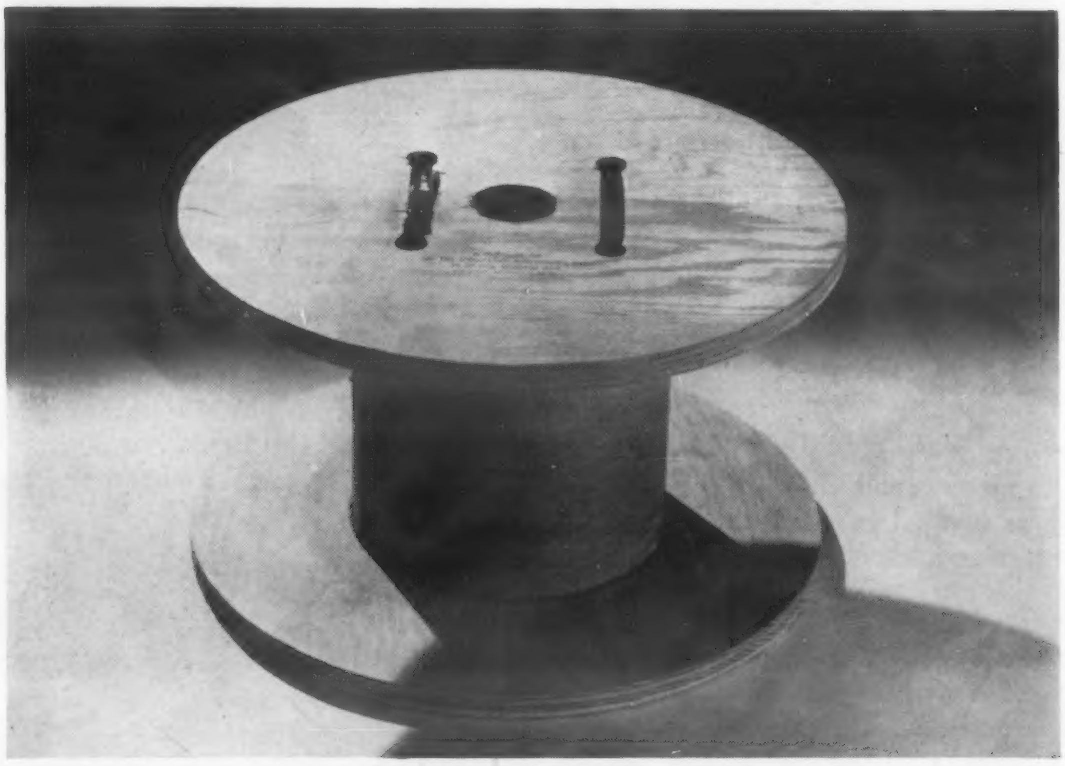




Metal-faced wood-core sandwich materials, plain and perforated. Faces are of 2S aluminum and core is basswood veneer.



Sandwich structures of silicone foam core and silicone-glass laminate faces combine heat stability with high ratio of compressive strength to weight.



Plywood finds use in this disposable wire reel.

used where thermal insulation is the primary property determining selection.

Wood Laminates

Many of these are plywoods with low-cost wood cores, and have already been mentioned. With balsa wood as a core, lighter weight is purchasable at higher cost. A typical structure in the sandwich type of laminate is a helicopter blade made by Bell Aircraft Corp. for large military aircraft of this type. One blade for the two-bladed propeller is about 12 ft long. The core consists of blocks of balsa wood, adhesive bonded together. The faces are longitudinal strips of spruce, running the length of the blade, and leading and trailing edges are shaped from strips of birch. The balsa provides lightness of weight, the spruce lightness with strength, and the birch hardness and wear resistance. To provide additional strength and stiffness, a steel bar runs through the composite at the leading edge of the blade. This also helps in attaching the laminate to the hub. All wood constituents are adhesive bonded, and a film of plastics is applied over the sandwich construction to provide water resistance to the whole.

Another sandwich construction in wood makes use of blocks of wood fiber, resin treated, for the core. This is the Tee-Cor Door, made by the Morgan Co. The fiber blocks are laid in a T-pattern, with wood faces and edge strips adhesive bonded together. Doors, table tops, furniture panels, and similar articles are made with paper honeycomb cores and faces of plywood and other materials. Several furniture companies are using chipboard as a core material, with wood facings to match other parts of the piece.

Wood-faced paper honeycomb is usually made with a lightweight plywood in the faces. Strength is controllable by selecting the material and thickness for the faces, or the thickness of the core.

Paper Laminates

The most familiar of the paper laminates is corrugated container board, in which two faces of paperboard are separated by a corrugated sheet of paper or paperboard. This material is low in cost, with excellent strength and stiffness combined with light weight. As the adhesives used in making ordinary corrugated container board are not water-resistant, the material is unsuited for exposure to weather or to high humidity.

A use for which moisture resistance is a prime consideration is in the radar antenna housing in aircraft. Here metal is unsuitable because of its shielding effect. Hygroscopic materials, such as the ordinary plywood first used, also shield the antenna, so special resin-impregnated paper honeycomb was produced for this purpose. Here both the strength of the laminate and its special property of passing ultrashort-wave radiations were required. A sandwich material in which the corrugated board itself serves as faces over a plywood core is used as a lightweight shipping container material.

Metal-Faced Laminates

Metal-Faced Wood—Facing materials most commonly used are steel, zinc coated steel, aluminum, and stainless steel. The metal facing is usually about 24-gage, or about 0.025 in. thick, though both heavier and lighter thicknesses are used. The core is most commonly Douglas fir plywood, resinous glue bonded for moisture resistance, and in thicknesses of ¼ in., ⅜ in., ½ in., and ¾ in. Other woods and other thicknesses are sometimes used for special purposes.

The metal used may be finished in any of several ways, or may be rigidized (surface embossed) for greater stiffness. In certain grades (architectural grades) a thin veneer of lauan (Philippine mahogany) is placed between the metal facing and the ply-

wood core to minimize the grain pattern show-through on the metal face. This construction increases dent resistance.

Care must be taken to protect raw edges of metal-faced plywoods against moisture and chemicals. This may be done by ordering the sheet stock slightly oversize, cutting down to size, and bending the metal facing over the raw edge. Such operations can usually be done best at the plant of the supplier, and careful ordering to size and shape is recommended.

Metal-faced plywood is used for truck and trailer side panels, railway car interior bulkheads and doors, kitchen cabinets, instrument boxes and cabinets, truck doors, locomotive sheathing, trolley car and bus doors, and many other applications.

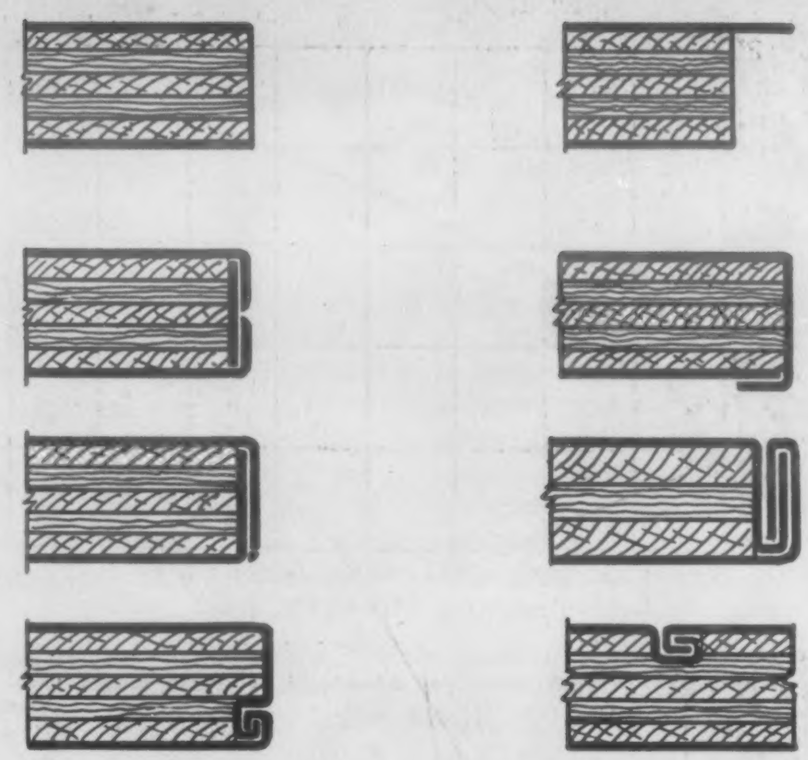
Honeycomb Materials—Aluminum sheet may be laminated to an aluminum foil honeycomb to obtain a sandwich material of many valuable properties. Use of the all-metal composition permits the adhesive bond to be cured at a somewhat higher temperature, above 300 F, than if organic constituents were used in the sandwich. The bond is improved by the higher-temperature cure, showing higher strength and less tendency to creep.

The all-aluminum sandwich has excellent physical properties, and is resistant to corrosion, high humidity, and temperature changes. It has found use in aviation structures, for table tops aboard navy destroyers, etc.

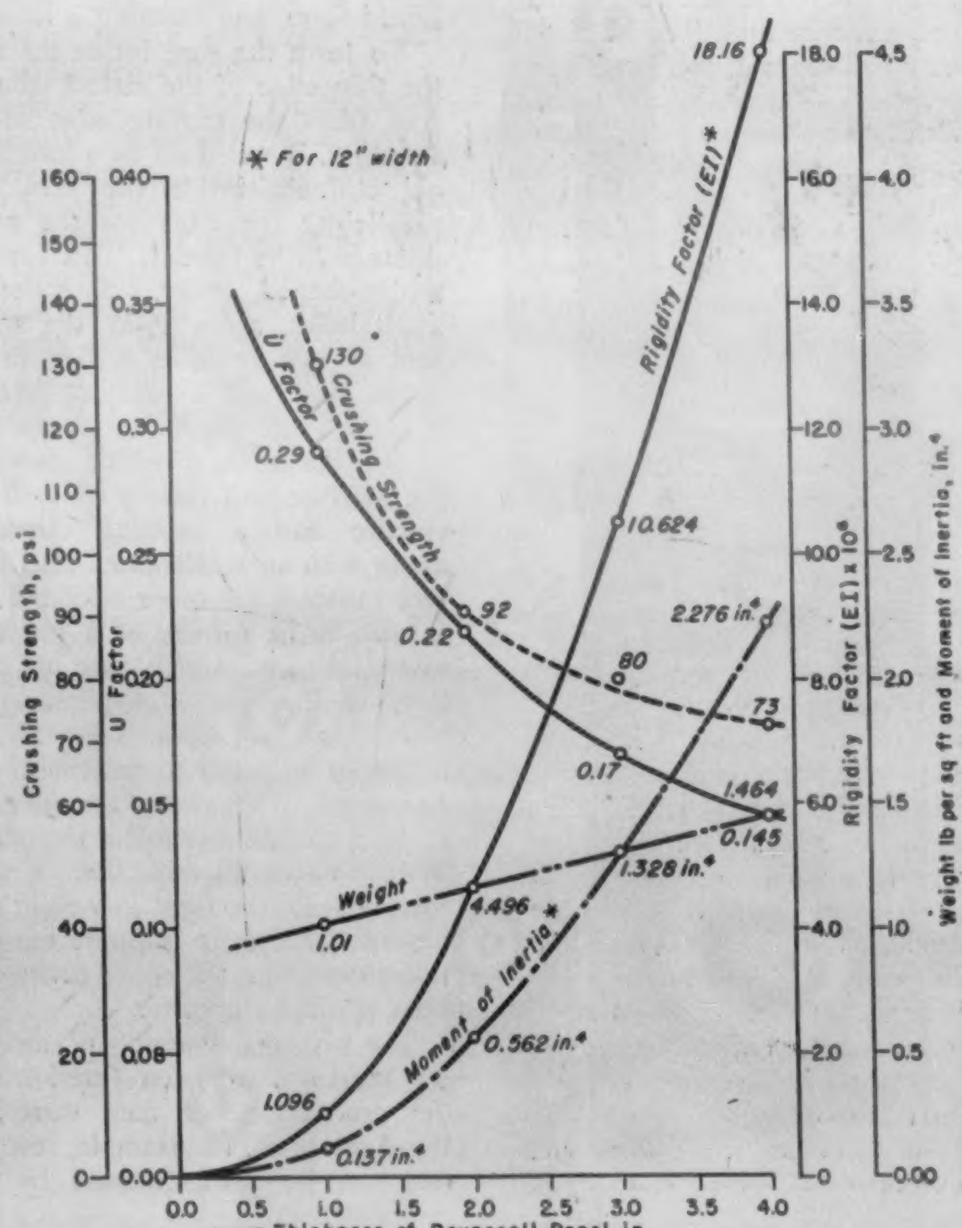
Aluminum sheet laminated over a paper honeycomb core is offered under the trade name Reynocell. It is used for doors, table tops, etc.

A new sandwich material is made with ordinary window glass for faces, adhesive bonded to an aluminum foil honeycomb core. It transmits diffused light. Colors can be obtained by tinting the adhesive layer. The material has excellent bending strength, and is suggested for use in doors, table tops, and panelling.

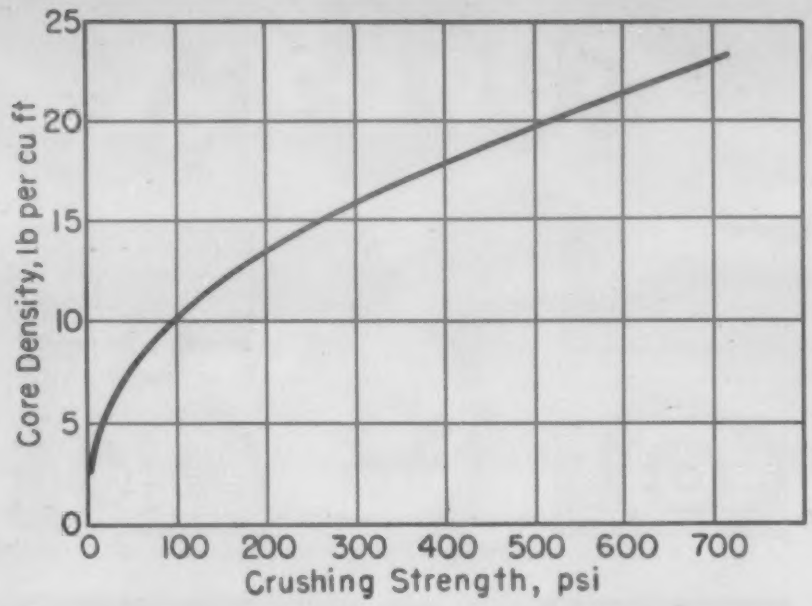
Foamed Sandwich Materials—The foaming of plastics in cavities in aluminum and magnesium, and especially in aircraft construction using these metals, has developed into one of the important uses of sandwich materials. One important use is in the trailing edges of wings, control surfaces, and similar parts of the airfoil that narrow down so as to be difficult of access. In these areas, possibly the last foot of width of the surface, the section has narrowed



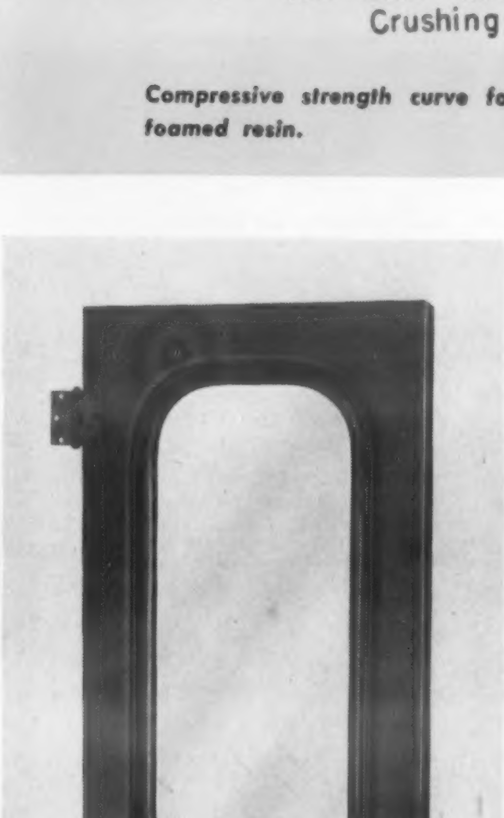
Types of edges used on metal-faced plywood-core laminates to seal against moisture and increase strength.



Properties of figure eight honeycomb paper-core aluminum-faced panels.



Compressive strength curve for Armofoam, a di-isocyanate type foamed resin.



This door for railway caboose is made of steel clad wood.

down so that fastening of metal ribs and stiffeners inside the skin is difficult. To prevent flutter of the skin, reinforcing is necessary. The most satisfactory way of providing it is by pouring in a plastics material in liquid form, and foaming it in place.

To form the core inside the skin, the thin edge of the airfoil, about a foot from the trailing edge of the structure, is sealed off by a longitudinal stiffener inside the skin, and paralleling the edge for the entire distance to be treated. This forms a wedge-shaped cavity. A series of small holes, about ½-in. dia and a foot or two apart, is drilled in the upper skin, and a foaming mixture is poured into the holes. In the case of an isocyanate foaming material, the mixture will consist of a di-isocyanate and a reacting chemical, along with an accelerator. This mixture causes a gas to be liberated and a foam to be formed of a predetermined density, which sets up to a solid in a predetermined time.

With an 8-ft wing, about 10 min might be required to fill the cavity, and about 10 min more for the foam to form and solidify inside the cavity. Within about 20 min, then, a reinforcing material, light in weight and providing uniform support for the skin throughout the entire cavity, has been applied complete.

The principal foaming plastics on the market have been listed under the descriptions of core materials. For Armofoam, for example, reaction rate can be predetermined by the composition of the foaming liquid so that the foam will require a time of from 2 min to approximately 15 min to form and set up. Density is controllable by the composition of the mixture also, with densities of 4 lb, 8 lb, or 12 lb per cu ft obtainable without difficulty. Strength will depend upon density, with a 4-lb foam having about one-fourth the strength of one of 8 lb density. The foam is self-supporting at the end of the foaming period, and possesses fair strength about half an hour later. Strength may increase somewhat during the next 24 hr.

Hollow steel airplane propellers have been given a reinforcing core in the same manner as the core is foamed in place in aircraft wings and control surfaces. Both di-isocyanate and foamed rubber vulcanizates have been used. After the hollow steel blade has been forged, a length of resistance wire for de-icing is placed in the blade; the rubber strip, into which have been incorporated a gassing agent and a vulcanizing compound, is placed inside the blade. Heat is applied; the rubber is foamed, and vulcanized to hard rubber to provide the needed reinforcement to the steel surfaces.

The greatest obstacle to the wider use of all of these dead-air core sandwiches, including both the foamed cores and the honeycombs, is high cost. This has limited their market, to a considerable extent, to the aircraft industry, which can pay a high premium for weight saving. Other applications are beginning to open up, however.

When the resin cannot be foamed in place, its application to sandwich construction proceeds along different lines. It is possible to cut a piece of the rigid foamed material to the size and shape of the cavity, to coat it or the inner walls of the cavity with an adhesive, and to force the core into place. This is arduous, the proper positioning and uniform contact of the core with the faces is problematical, and achieving a satisfactory bond is in doubt. Forcing the preformed core into some cavities would be impossible.

For these reasons the formed resins such as Strux and Styrofoam are most commonly used for sandwiches made in the open and assembled into the structure as a unit. They can be obtained as sheets usable for cores, or in blocks that can be sculptured or contoured to core form. Lamination may then be accomplished be-

tween dies. These materials can be machined to close tolerances. They can be foamed under heat also, usually applied as hot water or steam.

While the foams can be prepared in a range of densities, from about 5 lb per cu ft upward, it is helpful to think of them as slightly lighter than balsa wood. Both are used in the aircraft industry as core materials in laminates of polyester resins having glass fiber reinforcement. They can be also laminated with wood, aluminum, and other facing materials. Because of excellent electrical properties, they are used as cores in radomes (radar antenna housings); they go into control surface reinforcement, and into walls and panels also. They find application in the ribs and posts in military shelters, in shipping containers, and other military and nonmilitary items.

Plastic Laminates

The plastics used as foamed cores have already been described, and many of the plastics-faced laminates have been mentioned. Plywood makes an excellent core. It is faced with paper-, cotton-, and glass fiber-reinforced phenolics, melamines, and ureas for use in table tops, kitchen work tables, chair seats, and in many industrial applications. Plywood faced with phenolic-impregnated cellulose fiber finds many uses where good corrosion resistance and abrasion resistance are desired.

Cores of cotton cloth honeycomb and glass cloth honeycomb impregnated with plastics, and faced with aluminum, wood, or laminated plastics, are used as high strength sandwiches in aircraft construction. Cotton honeycomb is superior to paper honeycomb where repeated impact is a factor, and in physical properties generally, but is not equal to aluminum foil honeycomb. Where thermal insulation is an added condition, cotton honeycomb has advantages over aluminum foil.

Insulating Laminates

Sandwich construction is useful for materials used for electrical or thermal or sound insulation, fire resistance, and for vibration isolation. Thermal inuslation is measured by the number of heat units passed through a unit thickness over a unit area per hour per degree F of temperature differential. It is called the K factor. Sound insulation is rated in the number of decibels the noise level is reduced in transmission, or by the degree of sound absorption in a room.

Laminates serving as insulators include many of those already described. Even the metal-faced plywoods, which are not particularly good thermal insulators, find use as doors and in structures in refrigerated trucks and in walk-in refrigerators, where their combination of good strength, easily cleaned surface, moisture resistance, and relatively low heat transmission are useful.

Metal-faced thermosetting plastics sheets and metal-faced ceramic wafers are used in subminiature standardized electronic circuits. The unwanted portion of the metal facing, usually copper, is etched away or otherwise removed, having a a conductive pattern on the nonconductive base. These circuits, originally printed on ceramic wafers, formed the vital part of the proximity fuse in wartime, and are now used in hearing aids and radio circuits.

Sandwiches having a glass-reinforced polyester resin as the core, with copper foil for the faces, are much used for electronic circuits that have now been standardized and miniaturized. Television and radio receivers may make use of these wafers to reduce space and weight in complicated circuits.

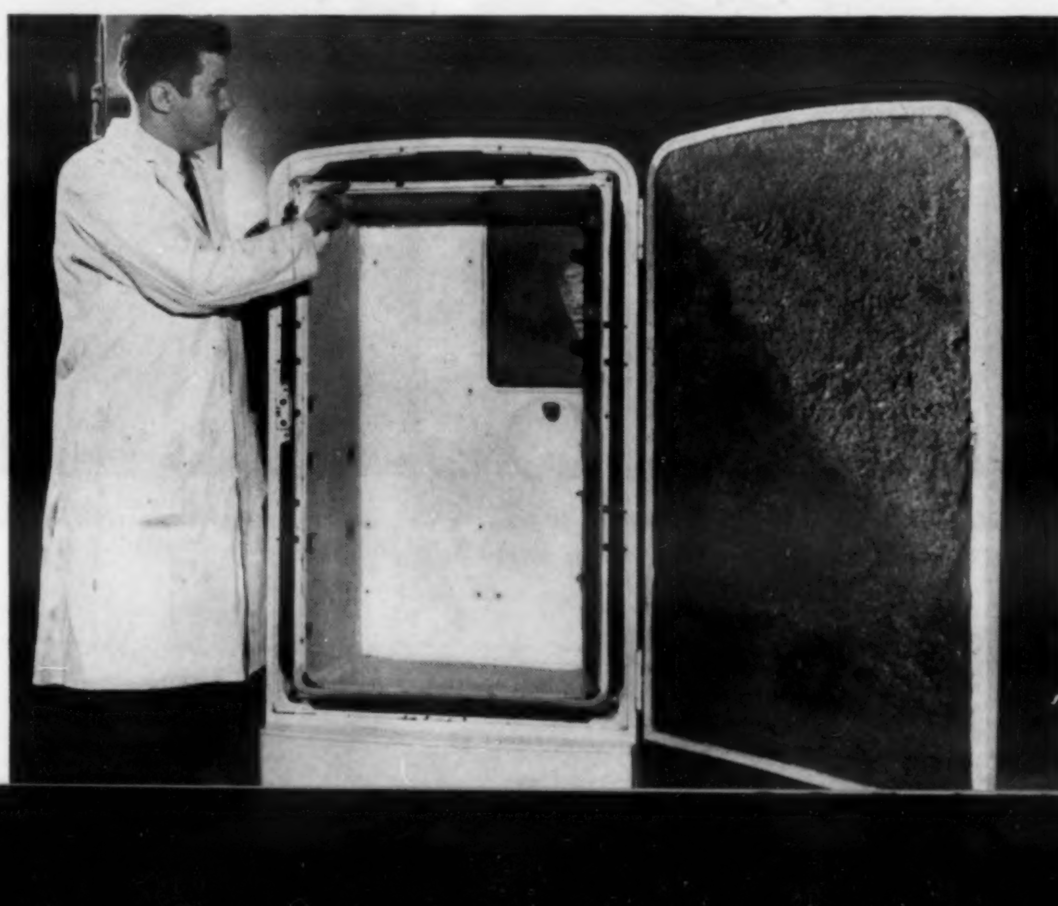
Corkboard, begasse (sugar cane) fiberboard (Celotex), and similar loosely compacted vegetable compositions become the cores in heat insulating sandwiches when faced with plywood, plastics, laminates, etc.

Heat insulation of the honeycomb materials is improved if the cells are filled with loose granules or powder of a poor conductor of heat, such as vermiculite or diatomaceous earth. This breaks up convection currents within cells of the honeycomb and reduces heat transmission.

There are several examples of laminated construction in the building field that do not come within the strict interpretation of the definition of industrial sandwich materials. These laminates, primarily for heat insulation, are usually mechanically fastened, and depend upon such materials as foamed glass (Foamglas), glass fiber bats, exploded concrete (Celocrete), rock wool, asbestos-cement board (Sheetrock, etc.) for thermal efficiency. Foamed polystyrene with wood faces is an important insulating material for railway refrigerator cars, refrigerated trucks, walk-in refrigerators, and smaller units.

An interesting material that is

A test installation of foamed-in-place phenolic in a 9-cu ft refrigerator.



formed into a semi-rigid board having fiber faces and a wood fiber core is offered under the trade name Cellufoam. The core is made moisture resistant and fire resistant by treatment with a phenolic resin; for added efficiency with light weight the resin is foamed. This sandwich is used in the insulating of refrigerated trucks, food storage containers, etc.

Weight is the most important factor in reducing sound transmission. The vibrations are converted into heat by the damping effect of a large mass. In absorption of sound vibrations inside a room, however, soft, fibrous, fissured surfaces are most effective. Soft, perforated tile, corkboard, bagasse board, etc., are good sound absorbers. Sound-absorbing laminates can be made by bonding faces of perforated plywood, hardboard, or metal over sound-absorbing cores. Low-density reconstituted wood boards, glass fibers, and the like are also good sound absorbers.

Vibration absorption is closely related to sound absorption. A laminate consisting of a rubber core between two strips of metal has been used as a motor mount to isolate the vibration of the machinery. Another sandwich consists of a flexible core between two sheets of steel, and is used for vibration damping in military applications.

Special Purpose Laminates

Special purpose sandwiches are usually materials of standard type that have been adapted to a particular use. The uses are so heterogeneous that they cannot be classified with other broad type applications.

A steel plywood-steel sandwich is made with a porcelain enameled surface that is receptive to chalk, and the product is offered under the trade name Chalkboard for use in railway, bus and airline terminals, conference rooms, or shop bulletin boards. The magnetic properties of the steel make it possible to affix notices to the board with the aid of a permanent magnet. The surface is ordinarily produced in a green color, as most restful to the eyes, but other colors can be obtained on order. Special designs, such as company emblems, ruled tubes, chart forms, and the like can be made an integral part of the surface of the writing board. Writing with chalk can be erased with a cloth or felt eraser, and the surface restored by a simple washing with water.

A facing of printed paper over a plywood core is used to give radio cabinets the appearance of beautifully figured wood. A resinous coating or impregnation makes the paper laminate resistant to ordinary handling, moisture, and scuffing.

A gasket is protected against abrasion by facings of light-gage metal. The core may be almost any type of gasket material, but the elastomeric plastics that are used for gasketing, such as Teflon, Sirvene, polyvinyl chloride, Saran, and Koroseal are especially interesting.

Another interesting development has been the production of flexible

This radar reflector, 4 ft wide by 17-½ ft long, is of sandwich construction with aluminum honeycomb core and weighs less than 100 lb. Left, forming reflector into a double curved parabola.

Phenolic foam (left) is used to fill blister voids (right) in aircraft carrier. Cover plates are removed to show how foam fills void spaces. Resin in liquid form is poured into void where catalyst causes reaction expanding it to 300 times original volume.

laminates, with two faces and a core, that should be suitable for gasketing and similar applications. One of these has a core of woven glass fibers, and is faced with outside films of vinyl polymers. The material is sold under the trade name Fortron. Another has a core of silicone elastomer and is faced with woven glass fibers.

The use of special cores in sandwiches for radomes has been mentioned. Here the property desired is high permeability to radiation of very short wave length, without impairment of that permeability due to absorption of moisture. Special grades of paper honeycomb, resin impregnated, and foamed plastics cores are in use.

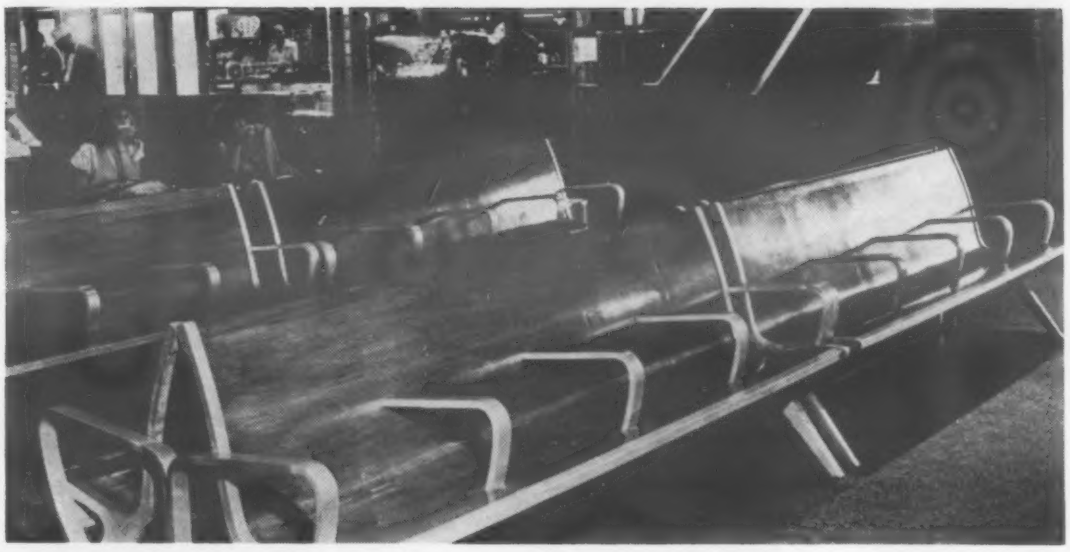
Sandwich materials find wide use for containers and packaging.

Fabricating the Sandwiches

After the sandwich is formed, it must sometimes be shaped, drilled, assembled into the structure for which it is intended, or otherwise processed. Only general rules can be set for the working of sandwich materials, in view of the many types of materials that may go into them.

Cutting—Sandwiches containing only wood or paper plies present no particular problem. Ordinary woodworking tools can be used. The bandsaw, the table saw, or the handsaw will perform satisfactorily. Edges may be protected by a calking compound, or by spraying with a chemical coating having low permeability to moisture, or, better, they may be protected by a wooden edging piece. Holes may be drilled with ordinary tools, but high speed steel drills are recommended for production, because of the abrasiveness of the adhesive.

For metal-faced sandwiches the accompanying guide on cutting operations may serve.



These benches were made by molding wood-face, wood-core sandwich material in heated forms.

Operation	Aluminum-faced	Steel-faced
Sawing	bandsaw tablesaw handsaw (crosscut)	bandsaw . . . . hacksaw (difficult to use)
Drilling	drill press electric hand drill	drill press electric hand drill (slow speed)
Routing	with high speed steel cutters; carbide-tipped cutters recommended for production.	possible, but difficut

The foamed plastics present no problem. They may be sawed with the bandsaw, tablesaw, or with handsaws. The phenolics tend to be abrasive, and high speed steel or carbide-tipped cutters are recommended for production. Drilling may be done with a drill press or electric hand drill.

For the metal-faced sandwiches, raw edges may be sprayed with a protective and moisture-resistant coating, or the sheet may be cut oversize, the core cut out to size, and the metal bent back over the core.

Fastening—Most types of mechanical fasteners may be used. If the panel is to be bolted into an assembly, proper precautions must be taken to seal the panel against moisture at the point of attachment. Any type of rivet may be used. Rivets through the panel must be set with a spinner tool to prevent buckling of the shank in the core. Sheet metal screws may be used on all types of sandwiches; reinforcing blocks must be placed at the point of attachment at the time the laminate is produced.

A type of rivet having a broad head is recommended by an important laminates producer for use with its wood- and metal-faced laminates. This rivet, called the Southco Rivet, provides more bearing area than the standard types of rivets intended for use in metals. Another rivet intended for use in metal-faced plywood is the Met-L-Wood Split Rivet. This rivet is used for attaching pieces to the metal-wood laminate, and eliminates the need for drilling holes in the plies. The rivet pierces one metal-clad surface, then spreads and anchors itself in the core without piercing the other metal layer. A grooved punch to start the rivet, a bucking bar to back up on the plain side of the laminate and a hand hammer are all the tools required.

In many cases where a structural assembly is to be made, the loads can be carried directly into one skin, and attachment can be made with drive screws or drive rivets. With all of the low-density core sandwiches, reinforcing blocks should be inserted at the point of attachment at the time the sandwich is made.

Soldering, Brazing, Welding—Metal-faced sandwiches may be soldered—steel without difficulty, aluminum only with considerable care. Brazing is also possible, but the greater amount of heat needed precludes its use with laminates having paper honeycomb cores or other cores of low heat resistance. Spot-welding is possible, but usually leads to distortion of the metal.

Forming—Certain grades of laminates are formable after construction of the sandwich. Forming grades of metal-faced plywood, having an overall thickness of 1/8 in., and including two faces of 0.010-in. stainless steel or two faces of 0.015-in. aluminum, or combinations of these faces, may be roll-formed to tubes or brake-formed to rectangular tubular sections. This material may be edge-cut on shears. Postforming of other sandwich materials is under study.

Acknowledgments

Personnel or literature of the following companies have been consulted in the preparation of this Manual:

Aluminum Co. of America
American Latex Products
Armour & Co.
Armstrong Cork Co.
Bakelite Co., Div. of Union Carbide & Carbon Corp.
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MATERIALS & METHODS
March · 1954
Number 271

Materials Engineering File Facts

Hardness Conversion Tables

Relationships between Values Determined on Rockwell, Rockwell Superficial and Tukon Hardness Testers and Values Determined on Other Testers.

Although conversion tables dealing with hardness can only be approximate and never mathematically exact, it is of considerable value to be able to compare different hardness scales in a general way.

This table is based on the assumption that the metal tested is homogeneous to a depth several times as great as the depth of the indentation because different loads and different shapes of penetrators would, in metal not homogeneous, penetrate—or at least meet the resistance of—metal of varying hardness, depending upon the depth of the indentation. Hence, no recorded hardness value would be valid to an extent that could be confirmed by another person unless shape of penetrator and actual load applied are both specified.

The indentation hardness values measured on the various scales depend on the work hardening behavior of the material during the test and this in turn depends on the degree of previous cold working of the material. The B-scale relationships in the table are based largely on annealed metals for the low values and cold worked metals for the higher values. Therefore, annealed metals of high B-scale hardness such as austenitic stainless steels, nickel and high nickel alloys do not conform closely to these general tables. Neither do cold-worked metals of low B-scale hardness such as aluminum and the softer alloys. Special correlations are needed for more exact relationships in these cases.

Hardened Steel and Hard Alloys

C 150 Kg. Brale — Rockwell Hardness Tester	A 60 Kg. Brale — Rockwell Hardness Tester	D 100 Kg. Brale — Rockwell Hardness Tester	15-N 15 Kg. N Brale — Rockwell Superficial Hardness Tester	30-N 30 Kg. N Brale — Rockwell Superficial Hardness Tester	45-N 45 Kg. N Brale — Rockwell Superficial Hardness Tester	Diamond Pyramid Hardness 10 Kg. ◆ — Square Base Diamond Pyramid—136° Apex Angle	Knoop Hardness 500 Gr. & Over — Knoop Elongated Diamond	Brinell Hardness 3000 Kg. ● — Brinell Hultgren 10mm. Ball	G 150 Kg. 1/16" Ball — Rockwell Hardness Tester
80	92.0	86.5	96.5	92.0	87.0	1865	—	—	—
79	91.5	85.5	—	91.5	86.5	1787	—	—	—
78	91.0	84.5	96.0	91.0	85.5	1710	—	—	—
77	90.5	84.0	—	90.5	84.5	1633	—	—	—
76	90.0	83.0	95.5	90.0	83.5	1556	—	—	—
75	89.5	82.5	—	89.0	82.5	1478	—	—	—
74	89.0	81.5	95.0	88.5	81.5	1400	—	—	—
73	88.5	81.0	—	88.0	80.5	1323	—	—	—
72	88.0	80.0	94.5	87.0	79.5	1245	—	—	—
71	87.0	79.5	—	86.5	78.5	1160	—	—	—
70	86.5	78.5	94.0	86.0	77.5	1076	972	—	—
69	86.0	78.0	93.5	85.0	76.5	1004	946	—	—
68	85.5	77.0	—	84.5	75.5	942	920	—	—
67	85.0	76.0	93.0	83.5	74.5	894	895	—	—
66	84.5	75.5	92.5	83.0	73.0	854	870	—	—
65	84.0	74.5	92.0	82.0	72.0	820	846	—	—
64	83.5	74.0	—	81.0	71.0	789	822	—	—
63	83.0	73.0	91.5	80.0	70.0	763	799	—	—
62	82.5	72.5	91.0	79.0	69.0	739	776	—	—
61	81.5	71.5	90.5	78.5	67.5	716	754	—	—
60	81.0	71.0	90.0	77.5	66.5	695	732	614	—
59	80.5	70.0	89.5	76.5	65.5	675	710	600	—
58	80.0	69.0	—	75.5	64.0	655	690	587	—
57	79.5	68.5	89.0	75.0	63.0	636	670	573	—
56	79.0	67.5	88.5	74.0	62.0	617	650	560	—
55	78.5	67.0	88.0	73.0	61.0	598	630	547	—
54	78.0	66.0	87.5	72.0	59.5	580	612	534	—
53	77.5	65.5	87.0	71.0	58.5	562	594	522	—
52	77.0	64.5	86.5	70.5	57.5	545	576	509	—
51	76.5	64.0	86.0	69.5	56.0	528	558	496	—
50	76.0	63.0	85.5	68.5	55.0	513	542	484	—
49	75.5	62.0	85.0	67.5	54.0	498	526	472	—
48	74.5	61.5	84.5	66.5	52.5	485	510	460	—
47	74.0	60.5	84.0	66.0	51.5	471	495	448	—
46	73.5	60.0	83.5	65.0	50.0	458	480	437	—
45	73.0	59.0	83.0	64.0	49.0	446	466	426	—
44	72.5	58.5	82.5	63.0	48.0	435	452	415	—
43	72.0	57.5	82.0	62.0	46.5	424	438	404	—
42	71.5	57.0	81.5	61.5	45.5	413	426	393	—
41	71.0	56.0	81.0	60.5	44.5	403	414	382	—
40	70.5	55.5	80.5	59.5	43.0	393	402	372	—
39	70.0	54.5	80.0	58.5	42.0	383	391	362	—
38	69.5	54.0	79.5	57.5	41.0	373	380	352	—
37	69.0	53.0	79.0	56.5	39.5	363	370	342	—
36	68.5	52.5	78.5	56.0	38.5	353	360	332	—
35	68.0	51.5	78.0	55.0	37.0	343	351	322	—
34	67.5	50.5	77.0	54.0	36.0	334	342	313	—
33	67.0	50.0	76.5	53.0	35.0	325	334	305	—
32	66.5	49.0	76.0	52.0	33.5	317	326	297	—
31	66.0	48.5	75.5	51.5	32.5	309	318	290	—
30	65.5	47.5	75.0	50.5	31.5	301	311	283	92.0
29	65.0	47.0	74.5	49.5	30.0	293	304	276	91.0
28	64.5	46.0	74.0	48.5	29.0	285	297	270	90.0
27	64.0	45.5	73.5	47.5	28.0	278	290	265	89.0
26	63.5	44.5	72.5	47.0	26.5	271	284	260	88.0
25	63.0	44.0	72.0	46.0	25.5	264	278	255	87.0
24	62.5	43.0	71.5	45.0	24.0	257	272	250	86.0
23	62.0	42.5	71.0	44.0	23.0	251	266	245	84.5
22	61.5	41.5	70.5	43.0	22.0	246	261	240	83.5
21	61.0	41.0	70.0	42.5	20.5	241	256	235	82.5
20	60.5	40.0	69.5	41.5	19.5	236	251	230	81.0

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MATERIALS & METHODS
March • 1954
Number 271

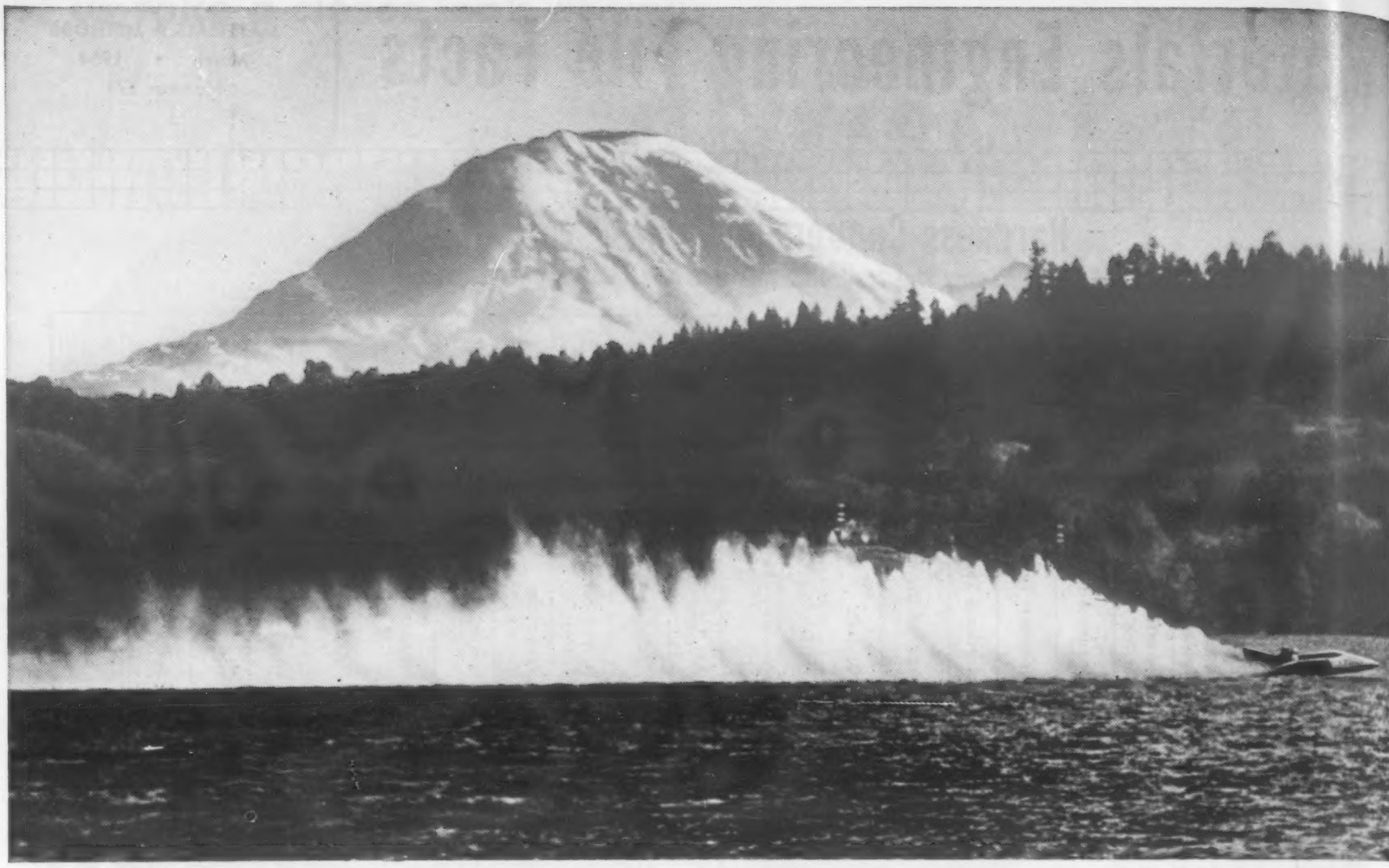
Materials Engineering File Facts

Hardness Conversion Table (Continued)

Soft steel, grey and malleable cast iron and most non-ferrous metals

B 100 Kg. 1/16" Ball Rockwell Hardness Tester	F 60 Kg. 1/16" Ball Rockwell Hardness Tester	G 150 Kg. 1/16" Ball Rockwell Hardness Tester	15-T 15 Kg. 1/16" Ball Rockwell Superficial Hardness Tester	30-T 30 Kg. 1/16" Ball Rockwell Superficial Hardness Tester	45-T 45 Kg. 1/16" Ball Rockwell Superficial Hardness Tester	E 100 Kg. 1/8" Ball Rockwell Hardness Tester	K 150 Kg. 1/8" Ball Rockwell Hardness Tester	A 60 Kg. Brale Rockwell Hardness Tester	Knoop Hardness 500 Gr. & Over Knoop Elongated Diamond	Brinell Hardness 500 Kg. 10mm. Ball Standard Brinell	Brinell Hardness 3000 Kg. D.P.H. 10Kg. Square Base Diamond Pyramid—136° Apex Angle
100	—	82.5	93.0	82.0	72.0	—	—	61.5	251	201	240
99	—	81.0	92.5	81.5	71.0	—	—	61.0	246	195	234
98	—	79.0	—	81.0	70.0	—	—	60.0	241	189	228
97	—	77.5	92.0	80.5	69.0	—	—	59.5	236	184	222
96	—	76.0	—	80.0	68.0	—	—	59.0	231	179	216
95	—	74.0	91.5	79.0	67.0	—	—	58.0	226	175	210
94	—	72.5	—	78.5	66.0	—	—	57.5	221	171	205
93	—	71.0	91.0	78.0	65.5	—	—	57.0	216	167	200
92	—	69.0	90.5	77.5	64.5	—	100	56.5	211	163	195
91	—	67.5	—	77.0	63.5	—	99.5	56.0	206	160	190
90	—	66.0	90.0	76.0	62.5	—	98.5	55.5	201	157	185
89	—	64.0	89.5	75.5	61.5	—	98.0	55.0	196	154	180
88	—	62.5	—	75.0	60.5	—	97.0	54.0	192	151	176
87	—	61.0	89.0	74.5	59.5	—	96.5	53.5	188	148	172
86	—	59.0	88.5	74.0	58.5	—	95.5	53.0	184	145	169
85	—	57.5	—	73.5	58.0	—	94.5	52.5	180	142	165
84	—	56.0	88.0	73.0	57.0	—	94.0	52.0	176	140	162
83	—	54.0	87.5	72.0	56.0	—	93.0	51.0	173	137	159
82	—	52.5	—	71.5	55.0	—	92.0	50.5	170	135	156
81	—	51.0	87.0	71.0	54.0	—	91.0	50.0	167	133	153
80	—	49.0	86.5	70.0	53.0	—	90.5	49.5	164	130	150
79	—	47.5	—	69.5	52.0	—	89.5	49.0	161	128	147
78	—	46.0	86.0	69.0	51.0	—	88.5	48.5	158	126	144
77	—	44.0	85.5	68.0	50.0	—	88.0	48.0	155	124	141
76	—	42.5	—	67.5	49.0	—	87.0	47.0	152	122	139
75	99.5	41.0	85.0	67.0	48.5	—	86.0	46.5	150	120	137
74	99.0	39.0	—	66.0	47.5	—	85.0	46.0	147	118	135
73	98.5	37.5	84.5	65.5	46.5	—	84.5	45.5	145	116	132
72	98.0	36.0	84.0	65.0	45.5	—	83.5	45.0	143	114	130
71	97.5	34.5	—	64.0	44.5	100	82.5	44.5	141	112	127
70	97.0	32.5	83.5	63.5	43.5	99.5	81.5	44.0	139	110	125
69	96.0	31.0	83.0	62.5	42.5	99.0	81.0	43.5	137	109	123
68	95.5	29.5	—	62.0	41.5	98.0	80.0	43.0	135	107	121
67	95.0	28.0	82.5	61.5	40.5	97.5	79.0	42.5	133	106	119
66	94.5	26.5	82.0	60.5	39.5	97.0	78.0	42.0	131	104	117
65	94.0	25.0	—	60.0	38.5	96.0	77.5	—	129	102	116
64	93.5	23.5	81.5	59.5	37.5	95.5	76.5	41.5	127	101	114
63	93.0	22.0	81.0	58.5	36.5	95.0	75.5	41.0	125	99	112
62	92.0	20.5	—	58.0	35.5	94.5	74.5	40.5	124	98	110
61	91.5	19.0	80.5	57.0	34.5	93.5	74.0	40.0	122	96	108
60	91.0	17.5	—	56.5	33.5	93.0	73.0	39.5	120	95	107
59	90.5	16.0	80.0	56.0	32.0	92.5	72.0	39.0	118	94	106
58	90.0	14.5	79.5	55.0	31.0	92.0	71.0	38.5	117	92	104
57	89.5	13.0	—	54.5	30.0	91.0	70.5	38.0	115	91	103
56	89.0	11.5	79.0	54.0	29.0	90.5	69.5	—	114	90	101
55	88.0	10.0	78.5	53.0	28.0	90.0	68.5	37.5	112	89	100
54	87.5	8.5	—	52.5	27.0	89.5	68.0	37.0	111	87	—
53	87.0	7.0	78.0	51.5	26.0	89.0	67.0	36.5	110	86	—
52	86.5	5.5	77.5	51.0	25.0	88.0	66.0	36.0	109	85	—
51	86.0	4.0	—	50.5	24.0	87.5	65.0	35.5	108	84	—
50	85.5	2.5	77.0	49.5	23.0	87.0	64.5	35.0	107	83	—

B 100 Kg. 1/16" Ball Rockwell Hardness Tester	F 60 Kg. 1/16" Ball Rockwell Hardness Tester	15-T 15 Kg. 1/16" Ball Rockwell Superficial Hardness Tester	30-T 30 Kg. 1/16" Ball Rockwell Superficial Hardness Tester	45-T 45 Kg. 1/16" Ball Rockwell Superficial Hardness Tester	E 100 Kg. 1/8" Ball Rockwell Hardness Tester	H 60 Kg. 1/8" Ball Rockwell Hardness Tester	K 150 Kg. 1/8" Ball Rockwell Hardness Tester	A 60 Kg. Brale Rockwell Hardness Tester	Knoop Hardness 500 Gr. & Over Knoop Elongated Diamond	Brinell Hardness 500 Kg. 10mm. Ball Standard Brinell
50	85.5	77.0	49.5	23.0	87.0	—	64.5	35.0	107	83
49	85.0	76.5	49.0	22.0	86.5	—	63.5	—	106	82
48	84.5	—	48.5	20.5	85.5	—	62.5	34.5	105	81
47	84.0	76.0	47.5	19.5	85.0	—	61.5	34.0	104	80
46	83.0	75.5	47.0	18.5	84.5	—	61.0	33.5	103	—
45	82.5	—	46.0	17.5	84.0	—	60.0	33.0	102	79
44	82.0	75.0	45.5	16.5	83.5	—	59.0	32.5	101	78
43	81.5	74.5	45.0	15.5	82.5	—	58.0	32.0	100	77
42	81.0	—	44.0	14.5	82.0	—	57.5	31.5	99	76
41	80.5	74.0	43.5	13.5	81.5	—	56.5	31.0	98	75
40	79.5	73.5	43.0	12.5	81.0	—	55.5	—	97	—
39	79.0	—	42.0	11.0	80.0	—	54.5	30.5	96	74
38	78.5	73.0	41.5	10.0	79.5	—	54.0	30.0	95	73
37	78.0	72.5	40.5	9.0	79.0	—	53.0	29.5	94	72
36	77.5	—	40.0	8.0	78.5	100	52.0	29.0	93	—
35	77.0	72.0	39.5	7.0	78.0	99.5	51.5	28.5	92	71
34	76.5	71.5	38.5	6.0	77.0	99.0	50.5	28.0	91	70
33	75.5	—	38.0	5.0	76.5	—	49.5	—	90	69
32	75.0	71.0	37.5	4.0	76.0	98.5	48.5	27.5	89	—
31	74.5	—	36.5	3.0	75.5	98.0	48.0	27.0	88	68
30	74.0	70.5	36.0	2.0	75.0	—	47.0	26.5	—	67
29	73.5	70.0	35.5	1.0	74.0	97.5	46.0	26.0	—	—
28	73.0	—	34.5	—	73.5	97.0	45.0	25.5	—	66
27	72.5	69.5	34.0	—	73.0	96.5	44.5	25.0	85	—
26	72.0	69.0	33.0	—	72.5	—	43.5	24.5	—	65
25	71.0	—	32.5	—	72.0	96.0	42.5	—	—	64
24	70.5	68.5	32.0	—	71.0	95.5	41.5	24.0	—	—
23	70.0	68.0	31.0	—	70.5	—	41.0	23.5	82	63
22	69.5	—	30.5	—	70.0	95.0	40.0	23.0	—	—
21	69.0	67.5	29.5	—	69.5	94.5	39.0	22.5	—	62
20	68.5	—	29.0	—	68.5	—	38.0	22.0	—	—
19	68.0	67.0	28.5	—	68.0	94.0	37.5	21.5	79	61
18	67.0	66.5	27.5	—	67.5	93.5	36.5	—	—	—
17	66.5	—	27.0	—	67.0	93.0	35.5	21.0	—	60
16	66.0	66.0	26.0	—	66.5	—	35.0	20.5	—	—
15	65.5	65.5	25.5	—	65.5	92.5	34.0	20.0	76	59
14	65.0	—	25.0	—	65.0	92.0	33.0	—	—	—
13	64.5	65.0	24.0	—	64.5	—	32.0	—	—	58
12	64.0	64.5	23.5	—	64.0	91.5	31.5	—	—	—
11	63.5	—	23.0	—	63.5	91.0	30.5	—	73	—
10	63.0	64.0	22.0	—	62.5	90.5	29.5	—	—	57
9	62.0	—	21.5	—	62.0	—	29.0	—	—	—
8	61.5	63.5	20.5	—	61.5	90.0	28.0	—	71	—
7	61.0	63.0	20.0	—	61.0	89.5	27.0	—	—	56
6	60.5	—	19.5	—	60.5	—	26.0	—	—	—
5	60.0	62.5	18.5	—	60.0	89.0	25.5	—	69	55
4	59.5	62.0	18.0	—	59.0	88.5	24.5	—	—	—
3	59.0	—	17.0	—	58.5	88.0	23.5	—	—	—
2	58.0	61.5	16.5	—	58.0	—	23.0	—	68	54
1	57.5	61.0	16.0	—	57.5	87.5	22.0	—	—	—
0	57.0	—	15.0	—	57.0	87.0	21.0	—	67	53



WORLD'S FASTEST In a trial run, "Slo-Mo-Shun IV" streaks over Lake Washington, Seattle, at better than 180 miles an hour.

What keeps her from flying to pieces?

Death crowds right into the cockpit beside you when you drive a boat like that.

Strange things happen. Every little wave jars the hull like a rutted road. Your foot burns at the touch of the jiggling accelerator. Your eyeballs jounce around in their sockets like glazed marbles as you keep watch for a sight you never hope to see:

Screw heads popping off like bullets as the beaten hull breaks up around you from the incessant pounding.

But that is one threat you no longer need to fear—not when your boat is held together with Anchorfast. Stan Sayres (he owns and drives the world's fastest boat) can tell you: Not even the varnish has cracked where her joints are nailed with Anchorfast.

What is "Anchorfast?" Just about the most revolutionary fastener you ever did see (at right). Once you drive it in, it can split the handle of a claw hammer before it budges a thread.

Anyone could see what a wonderful idea it was when the manufacturer came to INCO with his question: "What metal?"

It had to be strong and tough for holding power, of course. And hard and stiff so you could drive it into hard wood without bending. Yet so rust-free and durable that it would outlast wood. Not too expensive either, mind you, for Anchorfast would sell in competition with ordinary brass screws.

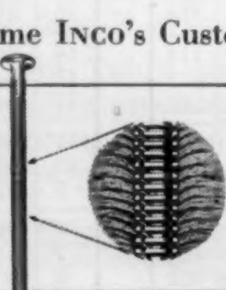
Monel fulfilled every requirement as if it had been an INCO Nickel Alloy especially made for Anchorfast.

Then came INCO's Customer Cooperation to help Independent Nail & Packing Co. find markets and spread the news of their Monel Anchorfast. (Come to think of it, this advertisement itself is an example of that cooperation.)

Today you find Anchorfast in boats from "Slo-Mo-Shun IV" down to slow plodding work boats, in cooling towers, catwalks, mushroom trays—for any NPA-approved use where joints must stay tight as long as the wood lasts.

Does Anchorfast remind you of a metal problem in some product of your own? Let's talk it over. The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

Drives like a NAIL...



HOLDS like a screw!

The holding power of Monel Anchorfast comes from its unique "biting tooth" design. The wedged wood fibers lock into the grooves like dozens of tiny vises. Like to try it yourself? Write for "Anchorfast Test Sample."

Inco Nickel Alloys

INCO

Monel® • "R"® Monel • "K"® Monel "KR"® Monel • "S"® Monel • Nickel Low Carbon Nickel • Duranickel® Inconel® • Inconel "X"® • Inconel "W"® Incoloy® • Nimonic® Alloys

For more information, turn to Reader Service Card, Circle No. 354

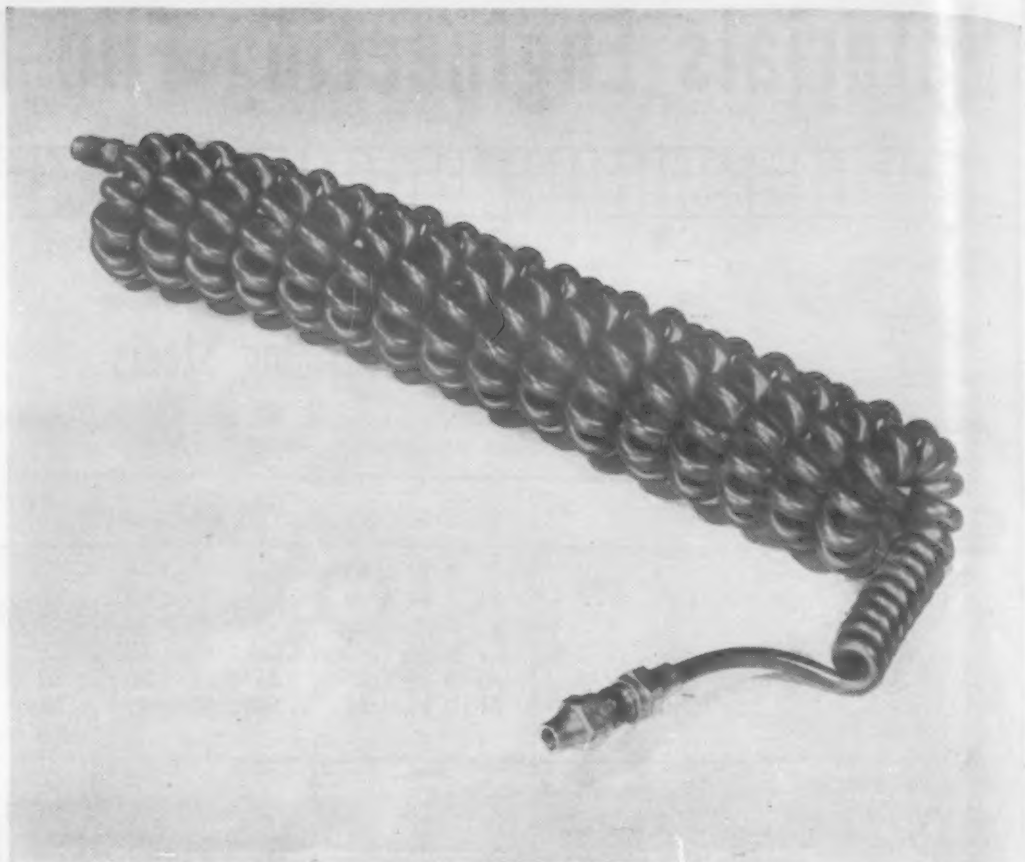
Materials Data Sheet

Nitriding Steels

Although certain other alloy and some stainless steels can be nitrided, several special steels containing aluminum, chromium and molybdenum yield the hardest cases. These steels are known as Nitralloys.

Nitralloy Type	135	135, Modified	N	EZ	GR
COMPOSITION—%	C 0.30/0.40 Mn 0.40/0.70 Si 0.20/0.40 Cr 0.90/1.40 Al 0.85/1.20 Mo 0.15/0.25	C 0.38/0.45 Mn 0.40/0.70 Si 0.20/0.40 Cr 1.40/1.80 Al 0.85/1.20 Mo 0.30/0.45	C 0.20/0.27 Mn 0.40/0.70 Si 0.20/0.40 Cr 1.00/1.50 Al 0.85/1.20 Mo 0.20/0.30 Ni 3.25/3.75	C 0.30/0.40 Mn 0.50/1.10 Si 0.20/0.40 Cr 1.00/1.50 Al 0.85/1.20 Mo 0.15/0.25 Se 0.15/0.25	C 1.25/1.50 Mn 0.40/0.60 Si 1.25/1.50 Cr 0.20/0.40 Al 1.00/1.50 Mo 0.20/0.30
PHYSICAL PROPERTIES					
Density, Lb/Cu In.	0.283	0.283	0.283	0.283	0.283
Thermal Cond, Btu/Hr/Sq Ft/Ft/F, @212 F	30	30	30	30	30
Coeff of Exp per F: 32–932 F	6.5×10^{-6}	6.5×10^{-6}	6.5×10^{-6}	6.5×10^{-6}	6.5×10^{-6}
Spec Ht, Btu/Lb/F:	0.11–0.12	0.11–0.12	0.11–0.12	0.11–0.22	0.11–0.22
Elect Res, Microhm-Cm @68 F:	27–29	27–29	27–29	27–29	27–29
Magnetic properties	Magnetic	Magnetic	Magnetic	Magnetic	Magnetic
MECHANICAL PROPERTIES					
Mod of Elasticity in Tension, psi	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$
Tensile Str, 1000 Psi: Hard and Temp (see notes)	138[a] 121[b]	159[a] 145[b]	132[c] 190[d]	126[a] —	108[e] —
Yield Str, 1000 psi: Hard and Temp	120 103	141 125	114 180	90[a f] —	84 —
Elongation in 2 in., %: Hard and Temp	20 23	18 20	22 15	17 —	17 —
Reduction of Area, %: Hard and Temp	58 62	56 64	59 43	44 —	19 —
Hardness, Bhn: Hard and Temp	280 230	320 285	277 415	255 —	— —
	The cases produced by nitriding these steels will have hardnesses in the range Rockwell 15N 94 to 95 excepting Nitralloy N which will range from about Rockwell 15N 92 to 93.				
Impact Str, Izod, Ft-Lb: Hard and Temp	65 80	— —	— —	— —	— —
Fatigue Str, (End Limit), 1000 Psi (g)	— — — —	45[g1] 24[g2] 90[g3] 80[g4]	— — — —	— — — —	— — — —
THERMAL TREATMENT					
Annealing Temp, F	1650–1700	1650–1700	1500–1550[h]	1650–1700	—
Quenching Temp, F	1700–1750	1700–1750	1625–1675	1700–1750	1625–1675
Tempering Temp, F	1100–1300	1100–1300	1100–1300	1100–1300	1100–1300
Nitriding Temp, F	930–1050 for periods ranging to 100 hr although 24 to 48 hr treatments are most widely used.				
FABRICATING PROPERTIES					
Hot Working Temp Range, F	1950–2200	1950–2200	1950–2200	1950–2200	1950–2200
Weldability	Can be welded by the atomic hydrogen process using a Nitralloy welding rod; also by flash welding.				
CORROSION RESISTANCE	Providing the outer skin or white layer is not removed, the nitrided case is resistant to alkalies, crude oil, natural gas combustion products, tap water and unagitated salt water; the case is attacked by mineral acids. Removal of the white layer greatly reduces resistance to attack.				
USES	Most uses based on resistance to wear, used in cylinder liners and barrels of aircraft engines; bushings, shafts, piston pins, spindles and thread guides, cams and cam shafts, rubber and paper mill rolls.				

NOTES:
[a] Core properties oil quenched from 1700 F, tempered at 1200 F.
[b] Core properties oil quenched from 1700 F, tempered at 1300 F.
[c] Core properties oil quenched from 1650 F, tempered at 1200 F, before nitriding.
[d] Core properties oil quenched from 1650 F, tempered at 1200 F, after nitriding.
[e] Core properties oil quenched from 1650 F, tempered at 1375 F for 5 hr.
[f] Proportional Limit.
[g] Steel heat treated to BHN 269 and (g1) unnitrided, unnotched; (g2) unnitrided with V notch; (g3) nitrided unnotched; (g4) nitrided with V notch.
[h] Must be cooled rapidly below 1150 F to avoid precipitation hardening.



High capacity small dimension copper heat exchanger.

Fabricating Special Purpose Copper Heat Exchangers

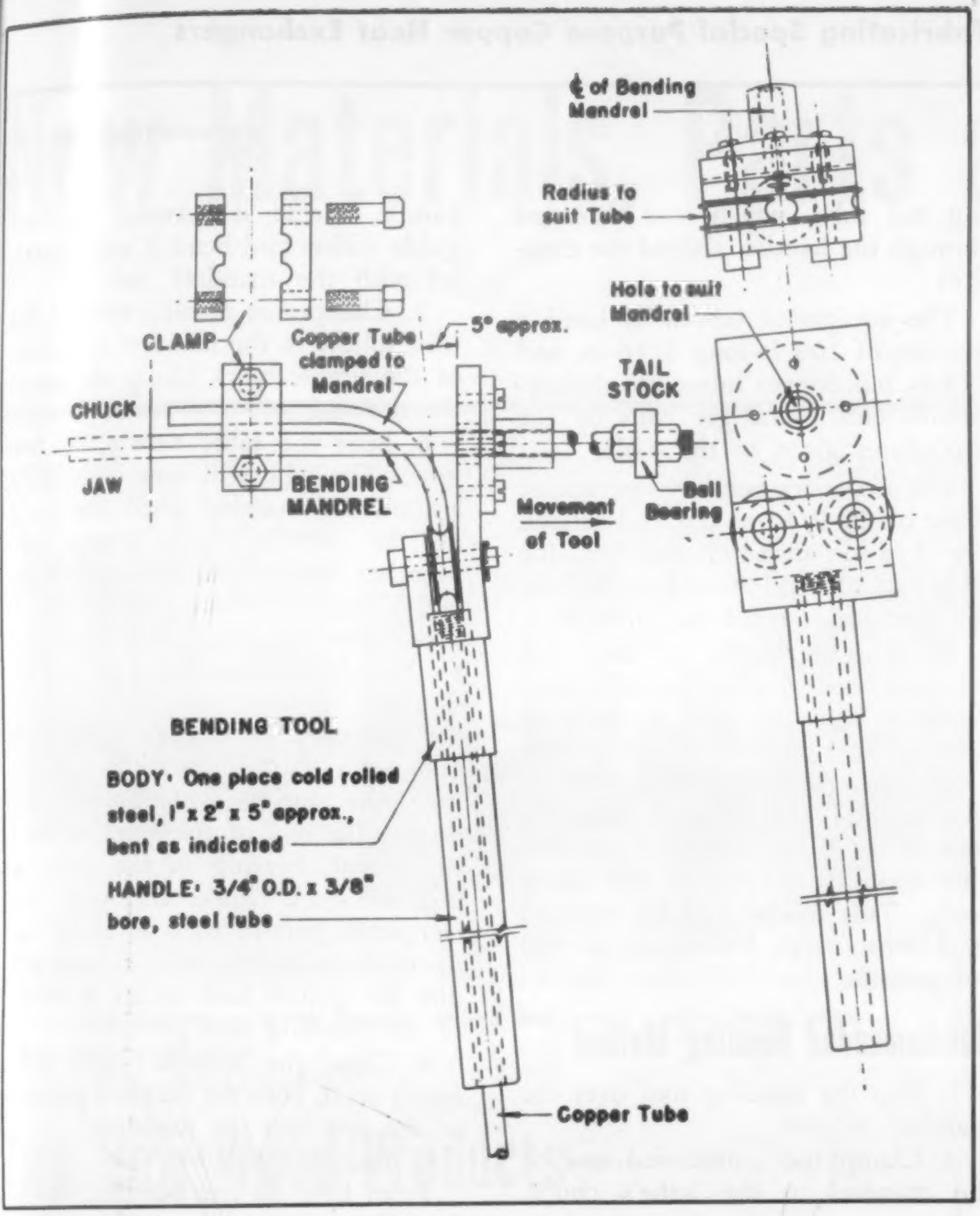
Flexible, coiled copper tubing offers a means of obtaining high capacity heat transfer in a small space.

● THE EXCELLENT DUCTILITY and heat conductivity of copper were employed to advantage in preparing high-capacity small volume heat exchangers for a special application requiring operating pressures of 1000 psi. To obtain adequate capacity, 100 ft lengths of deoxidized copper tubing were bent into closely spaced double coils.

Two sizes of copper tubing were employed in making these heat exchangers. One was 3/16 in. o.d. by 0.0325 in. wall, the other 1/4 in. o.d. by 0.0325 wall. The 3/16-in. tube required coiling around a 3/16-in. dia mandrel and subsequently around a 3/8-in. mandrel. The 1/4-in. tube was coiled around a 19/64-in. mandrel and subsequently around a 5/8-in. mandrel.

To prevent collapse of the tubes during the initial bending operations, they were filled with Cerrobend, a bismuth-base alloy melting at about 160 F. No difficulty was experienced in filling 100-ft lengths of mill coils of 3/16-in. tubing with the low melting alloy by immersing them in hot water, pouring the molten alloy into the tube and filling by gravity. However, difficulty was experienced in attempting to fill the 1/4-in. tubing by this procedure, since air traps persisted. These tubes were filled successfully by evacuating the tube and admitting the liquid Cerrobend.

Bending a 1/4-in. tube filled with Cerrobend around the 19/64-in. dia core presented difficulties. Tubes orange-peeled, cracked, and broke along the outer surface. Annealing to dead-softness only made matters worse. After considerable experimentation with tubes of several mills, it was discovered that the tubes which



Method of bending the copper coils.

by J. M. VAN NIEUKIRKEN, Copper and Brass Research Association

could not be bent satisfactorily had a grain size of 0.045 mm, while the grain size of the tubes which were bent successfully was 0.035 mm. In general, for these small size tubes to be bent satisfactorily around the short radii indicated, their grain size should lie between 0.022 mm and 0.035 mm.

Bending Equipment

Tooling for the bending operations was relatively simple. An ordinary engine lathe was used, with a hole through the spindle large enough for free passage of the finished coil, that is, at least twice the o.d. of the tube being bent plus the diameter of the core. The lathe had a universal chuck. Although not absolutely necessary, the tail stock was fitted with another universal chuck that would clamp a minimum diameter of 1-1/2 in.

The mandrel around which the tube was bent was a little over 3 ft long. One end of this mandrel was threaded and a standard ball bearing, centered on it by means of a slip-fit bushing, was clamped on between two common hexagonal nuts. The ball bearing race was held by the tail chuck's jaws, permitting the mandrel to rotate freely.

The tube bending tool is clearly shown in the accompanying figure. It consisted of three parts: 1) a handle, 12 in. long, made from a 3/4-in. o.d. by 3/8-in. i.d. steel tube, screwed into the body; 2) the body, made from a piece of 1-in. by 2-in. by 5-in. cold rolled steel bar milled out and drilled for the guide rollers, and provided with a hole large enough for the mandrel to pass through; 3) the two rollers for guid-

(Continued on page 142)

continued from page 141

ing the tube, which was threaded through the handle, around the mandrel.

The equipment served to bend a number of 100 ft long 3/16-in. and 1/4-in. o.d. copper tubes into doubly-wound heat exchanger coils by the procedures given in the table.

The secondary bending operations, those of the 9/16-in. o.d. coil around the 3/8-in. mandrel and of the 51/64-in. o.d. coil around the 5/8-in. dia mandrel offered no difficulties.

From short lengths of small i.d. tube the bending alloy can be readily removed by immersing the tube in boiling water and blowing with compressed air. Applied to longer lengths this method will remove only the bulk of the filler, leaving a considerable quantity attached to the inside walls. This residue can be removed by blowing with live steam of 100 psi pressure.

Recommended Bending Method

1. Slip the bending tool over the mandrel or core.
2. Clamp the unthreaded end of the mandrel in the lathe's chuck, letting a certain length protrude—this length depending on the diameter and relative stiffness of the mandrel rod.
3. Move up the tail stock and clamp the ball bearing on the mandrel's end in the tail stock's chuck jaws (or, if a standard center is used, until it fits into a corresponding depression in the end of the mandrel).
4. Place the coil of tube to be bent at a convenient distance from the lathe, uncoil and straighten enough of the tube to reach the lathe, pass the end through the handle, thread it between the two guide rollers and bend it until parallel with the mandrel rod.
5. Clamp this parallel end of the tube solidly to the mandrel by means of the simple block clamp shown in the drawing.
6. Start the lathe slowly, in low gear. The tube will now coil nicely around the mandrel until the body of the bending tool proper approaches the end of the mandrel on which the ball bearing is mounted. From now on the clamp fastening the tube to the mandrel is of no further use, hence:
7. Remove the clamp from both mandrel and tube, open the jaws of the lathe spindle wide but do not disturb the end of the mandrel held by its ball bearing in the jaws of the tail stock chuck, and push the completed part of the coil along the mandrel toward the lathe's chuck and into the spindle hole as far as safety of the bending tool permits.
8. Close the lathe's chuck jaws firmly on to both the finished portion of the coil and the mandrel.
9. Restart the lathe.

From here on the bending operation is merely a matter of proceeding with the bending of the tube until safety of the bending tool necessitates reopening of the lathe's chuck jaws, moving the completed portion of the coil farther into the spindle hole, re-closing the chuck jaws, and starting up again.

Acknowledgment

The author wishes to thank Norman Powell, Instrument Maker, Bryn Mawr College, who developed the bending method, for his assistance in preparing this article.

Attend the 1954 Materials Show and Conference

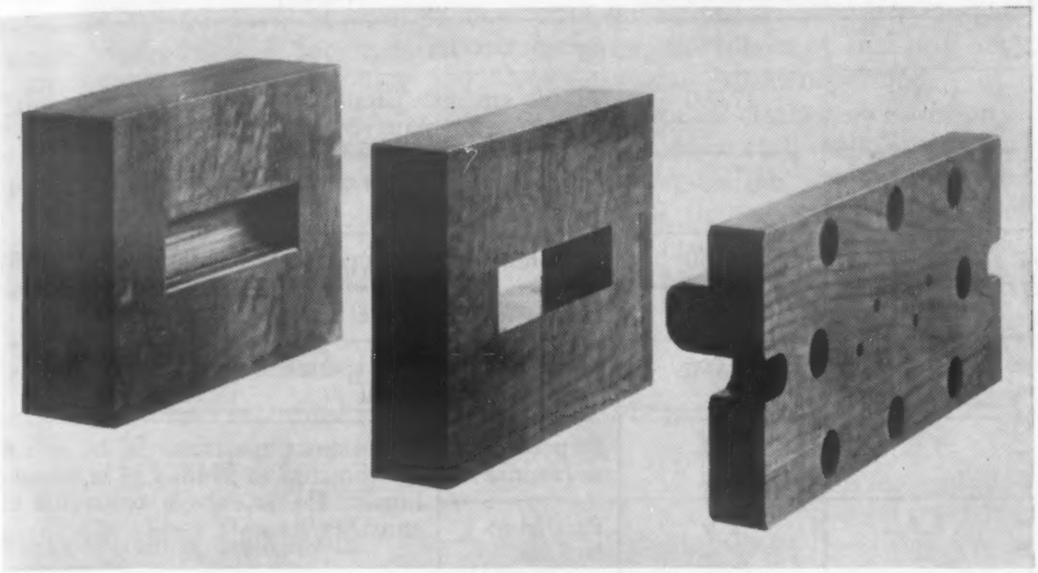
The second Basic Materials Show, the product development show which had its premiere in New York last June, will be held in the International Amphitheatre, Chicago, May 17-20.

Attendance at the first show exceeded advance estimates by a large number and as a result the exhibition space at the second exposition will be more than doubled and the number of exhibitors will be increased by about 50%.

Exhibits are limited to companies producing basic materials which go into the manufacture of other products.

New Materials, Parts and Finishes

...and Related Equipment



Raising tool showing male and female sections and center guiding block, made of Hy-du-lignum compressed wood.

Two New Wood Products—

Compressed Wood for Compressive Strength
Reconstituted Wood for Controlled Properties

Two new wood products have appeared on the materials scene. Hy-du-lignum, a dense lamination of compressed wood has been marketed essentially for tooling applications, while Castwood, a castable form of wood fibers, bound together with resin, is said to allow the economical fabrication of a variety of shapes with properties controllable to suit the end-use of the product.

Castwood

A castable, reconstituted wood product, made up of wood fibers and a resinous binder has been marketed by the *Forestrong Co.,* 1355 W. 190th St., Gardena, Calif. Control of the properties of the material is said to be gained by a method of controlling the size of the wood fibers used, the orientation of the fiber, the type of resin, and the preforming and pressing operations.

Recently there has been a blossoming of materials made of compressed "wood waste", bound and/or impregnated with a resinous material. According to the Forestrong Co., their Castwood differs from these in that controlled and oriented wood fibers are used which interlace and add to the strength of the end-product. The Castwood can be bored, sawed, planed, and sanded, though for many applications no machining is necessary since the product has a smooth surface from the mold.

There are four types of Forestrong products offered by the company: 1) Forestrong Castwood — molded, reconstituted wood products; 2) Forestrong Cast Hardwood—high density, hard surface Castwood; 3) Forestrong Casting Fiber — available in various fiber sizes with a choice of binders; and 4) Forestrong Castok —molding blanks which make possible molding without preform equipment.

Among recommended applications are ammunition packaging, chair backs and seats, doors, furniture components, flooring, glass frames, instrument boxes, printing plate blocks, and appliance housings and parts.

Hy-du-lignum

A laminated, compressed wood product with a specific gravity ranging from 0.96 to 1.31 and a production compression value of 35,000 psi, is now being marketed in this company by the *Hy-du-lignum Div., U.S.. Bobbin & Shuttle Co.,* Lawrence, Mass. The material is said to be well suited to tooling applications such as press form blocks, router templates and subassembly fixtures as well as for propellors, fan blades, and so forth.

Hy-du-lignum, now being manufactured in Great Britain, is made up of hardwood veneers which are kilned to a given moisture content, cut and assembled into packs, each veneer being interleaved with a phenolic resin film of 0.002-in. thickness.

(Continued on next page)

Strength of Forestrong Castwood is demonstrated on plate just off the press.

New Materials, Parts and Finishes continued

The packs are then submitted to high heat and pressure which bond them together to form laminated boards or sheets.

As opposed to compressed wood products that are impregnated with resin, Hy-du-lignum uses the phenolic as a binder only, thus retaining the machinability and the self-lubricating qualities of the wood. According to the company, the material weighs approximately 1/2 the weight of aluminum, 1/5 that of Kirksite, and 1/6 that of steel. It can be sawed, planed, turned, drilled and tapped; the surface may be scraped, sanded, scribed, polished, waxed, varnished or painted.

The material is available in two grades: High density grade 22/T/82, in standard thicknesses of 1/16 to 2 in. in increments of 1/16 in., and in thicknesses of 2 to 4 in. in increments of 1/4 in.; or medium density grade 22/T/60, in standard thicknesses of 1/16 to 2 in. in increments of 1/16 in., and thicknesses of 2 to 3 in. in increments of 1/4 in.

Average Physical Characteristics of Hy-du-lignum Grain of Alternate Laminae at 90 Degrees

22-T-82 Cross Grain High Density	22-T-60 Cross Grain Medium Density	Property
1.31	0.96	Specific Gravity
25,000	17,000	Tensile strength parallel to the laminae and to the grain of alternate veneers, Psi
35,000		Compressive strength on 20 mm cubes perpendicular to laminae, Psi
14,500	10,650	Compressive strength parallel to laminae, Psi
2720	2000	Shear strength parallel to laminae, Psi
22,000	14,000	Modulus of rupture specimens 14 x 1 x 1 in., 12 in. extreme centers, Psi
5.8	3.3	Perpendicular to laminae — Izod impact specimens 7/8 in. sq x 6 in.—notched to 7/8 in. x 1/2 in. section. Impact 2 1/2 in. above center line of notch, Ft/lbs.
2.4	1.9	Parallel to laminae — Izod impact specimens 7/8 in. sq x 6 in.—notched to 7/8 in. x 1/2 in. section. Impact 2 1/2 in. above center line of notch, Ft/lbs.
8500	3300	Hardness. Janka indentation load, lbs to embed 0.444" dia sphere to half depth perpendicular to laminae, Psi
82	60	Density, Lbs/ft^3

New High-Temperature Resistant Adhesive Bonds Metals

Metlbond 4021, a new high-temperature resistant adhesive, developed by the *Narmco Resins & Coatings Co.*, Costa Mesa, Calif., is said to exhibit tensile shear values of approximately 2000 psi at 260 F after 100 hrs exposure. This is said to raise the temperature level at which the minimum shear requirement called out in AF14164 can be met by approximately 150 F.

According to the company, bonds formulated with this process have shown room temperature shear values of over 4000 psi after 7 days immersion in JP-4 Jet Propulsion Fuel, as well as resistance to the fluids set forth in AF Spec 14164 and/or MIL-A-8331 USAF.

Surface Cleaning and Application

The most efficient precleaning process developed by Narmco for 24ST aluminum is as follows: Degreasing followed by immersion of plates for from 5 to 7 min in a solution of 30 parts by weight water, 10 sulfuric acid, and 4 sodium dichromate, which is held at a temperature of 160 F throughout immersion. The plates are washed in cold water, then oven-dried.

After cleaning, the plates are primed with Metlbond 2021 liquid adhesive (10% solids), with proper drying; Metlbond 402 unsupported tape is then applied; and the metal plates are assembled and cured. Recommended cure cycle is 100 psi pressure at 350 F for 60 min.

Test pads cured according to this cure cycle yielded these test results:

Type Test	Minimum Str Psi	Results of Bonds Using Metlbond 4021 Process Str Psi
Standard Temperature Shear Strength, RT	2500	4485
Elevated Temperature Shear Strength, 180 F	1250	2865
Elevated Temperature Shear Strength, 260 F		2054
Elevated Temperature Shear Strength, 350 F		1520
Low Temperature Shear Strength, −70 F	2500	3320
Standard Temperature Fatigue Strength, RT	650	*1
Low Temperature Fatigue Strength, —70 F	650	*2
Standard Temperature Long Time Strength, RT	1600	*3
Elevated Temperature Long Time Strength, 180 F	800	*4
Elevated Temperature Long Time Strength, 240 F		*5
Standard Temperature Bend Test, RT	150(lb)	233(lb)
Standard Temperature Impact Strength, RT	10(ft lb)	42.4
Low Temperature Impact Strength, −70 F	5(ft lb)	24.9
Shear Strength After 30 Days Salt Spray Exposure, Specification QQ-M-151	2000	4112
Shear Strength After 7 Days Immersion in JP-4 Jet Propulsion Fuel, RT		4429

*1 *Specimens loaded to 1050 psi have exceeded 10×10^6 cycles with no evidence of failure.*

*2 *Test incomplete. Specimens loaded at 1050 psi have completed 8.3×10^6 cycles with no evidence of failure. Specimens loaded at 1890 psi completed 377,000 cycles before test stopped due to failure in metal.*

*3 *Specimens have carried 2900 psi for 100 hours.*

*4 *Specimens have carried 2000 psi for 12, 20, and 35 hours respectively without failure.*

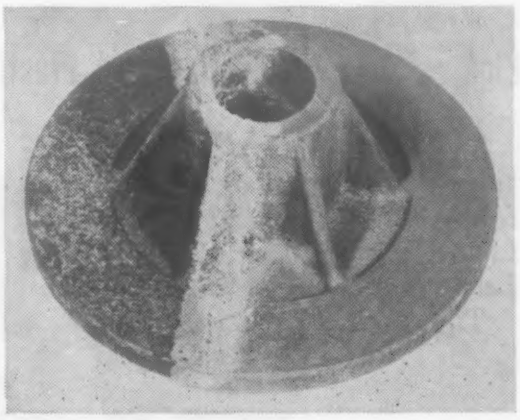
*5 *Specimens have carried 800 psi for 221 hours without failure. Maximum creep was .0135 in.*

Phosphoric Acid Type Cleaners for Large Heavy Parts

A group of phosphoric acid type cleaners, the 800 Series, intended for products that are too large to be phosphate coated with normal production methods, and for manufacturers whose production does not warrant elaborate equipment, has been developed by the *Detrex Corp.*, Detroit 32, Mich.

The new product, said to meet all government specs for this type of cleaner, can be compounded by the manufacturer to meet the particular requirements of each installation. It can be applied by brush, sponge, dipping, or flowed-on methods, and detergency, oil solvency, rust and scale removal can be incorporated.

This type of cleaner, in addition to cleaning the metal, deposits a fine-grained crystalline structure of iron phosphate that contains microscopic crevices into which organic finishes flow and become locked.



Before, right half, and after cleaning with new cleanser.

Barrel Finishing Compound

A new multiple purpose barrel finishing compound, said to produce brighter finishes in less time on a wide range of metals, has been marketed by *Minnesota Mining and Mfg. Co.*, 900 Fauquier St., St. Paul 6, Minn.

Called Honite brand Multi-Burnish compound, it is said to be usable with all types of barrel finishing media. During the first part of the operating cycle, the compound acts as a cleaner and permits rapid deburring. It then develops richer suds which act both as a lubricant and as a suspending agent, adding luster and color to the work pieces.

Among the features claimed by the company for their product are: 1) it can be used with most metals, and is recommended particularly for use with zinc, aluminum, magnesium, bronze, and mild and stainless steel; 2) it can be used with such finishing media as steel balls, natural stones, or aluminum oxide finishing chips; 3) it will not lose its lubricating qualities over prolonged runs; and 4) it is completely soluble.

One to two pounds of the compound are said to be sufficient for the average 16 by 30-in. compartment with full loads.

Organic Based Metallic Coatings

Four recently marketed coatings are said to offer a high degree of corrosion protection to metals without the need for heat during application. The coatings are composed of a high percentage of metallic powder (three zinc, one aluminum) bound together in a resin base. They can be brushed or sprayed on and are recommended as protection for structural iron and steel, ducts and piping, and much industrial equipment and machinery.

Aluminum Coating

Kolmetal, developed by the *Emjay Maintenance Engineers*, 327 Union Ave., Rutherford, N. J., is a mixture of over 80% pulverized aluminum in a plastic base. The coating achieved with two applications of the material, with a 4-hr drying time between applications, is said to air-harden to a surface which can be polished, ground, drilled or bent to a 45-degree angle and not chip or crack.

According to the company, tests on the coating indicate high resistance to atmospheric and sea water corrosion and a retention of finish and adhesion up to 160 F continuous service; 350 F intermittent service.

Three Zinc Coatings

One advantage claimed for the three zinc coatings over ordinary rust protective paints is their ability to stop rust creep from an exposed point or break in the coating. The coatings can also be applied over rusted areas to check further rust spread.

ZRC, a new paint marketed by the *Sealube Co.*, Wakefield, Mass., contains 93 to 95% zinc powder in an organic base, and should preferably be brushed on, though it may be sprayed. When used as a primer, the resulting zinc coat is said to contain 1/4 oz of zinc per sq ft.

Galvicon, a compound marketed by the *Galvicon Corp.*, 40 W. 29th St., New York 1, is said to result in a coating of approximately 96% metallic zinc after drying.

Dimetcote No. 3, marketed by the *Amercoat Corp.*, 4809 Firestone Blvd. South Gate, Calif., is said to contain approximately 80% metallic zinc in the organic base.

Liquid Resins for Reinforced Plastics Tooling

Special equipment or facilities are unnecessary in the fabrication of reinforced plastics tooling with Hysol Liquid Resins developed by *Houghton Laboratories, Inc.*, Olean, N. Y.

The resins are used in combination with glass fiber fabrics for tooling applications such as spotting racks, checking fixtures and assembly jigs. The use of reinforced plastics for these applications is said to allow multiple duplications from original models, and to ease design modifications and repairs.

The company offers kits which contain everything required for evaluation of reinforced tools, including complete instructions.

New General Purpose Aluminum Alloy

A new aluminum alloy, said to bridge the gap between the lower strength 61S and the higher strength, hard 24S and 14S, has been developed by the *Harvey Aluminum Co.*, Torrance, Calif.

The new alloy, 66S, is said to offer the fabricating advantages of the 61S, yet maintain yield strengths similar to that of the 24S alloys. According to the company, the new alloy is also similar to the 61S alloys in lower cost, corrosion resistance and ease of welding as compared to the harder alloys.

Company metallurgists guarantee a tensile strength of 50,000 psi for 66S material up to ¼ in. thick, a yield strength of 45,000 psi with an 8% elongation. Higher strengths are guaranteed in ¼-in. material and over.

Alloy 66S is expected to satisfy many industrial design demands, including the building industry, truck and trailer, aircraft, heavy construction, and general parts fabrication.

Silicone Rubber Has High Tear Strength

A new elastomer, developed by the *Plastics Div., General Electric Co.*, Decatur, Ill., is said to have a tear strength averaging 190 psi. Called Super-Tough Silicone Rubber, the material is available in three grades, 15060, 15080 and 15081, and is said to retain the thermal properties of silicones, but with greater tear strength and oil resistance. It maintains flexibility over a range of —65 to 550 F.

"O" rings and gaskets made of the material have been used satisfactorily as seals for synthetic base oils at temperatures of 375 F. It is also recommended for molded ducts and connectors for hot air lines and in chemical processing equipment where high temperatures, pressure, or vacuum exist.

Metal Cleaner Removes Quenching Oils

A non-corrosive washing compound has been developed by *Ipsen Industries, Inc.*, 715 S. Main St., Rockford, Ill., for the removal of oil, grease, lubricants, soils, lapping and drawing compounds from ferrous metals. The non-caustic compound is said to be mild and will not harm skin or clothing. In addition, it will not corrode or etch finished metal parts.

The compound is suitable for both batch and spray type washers, and the degreasing agent will produce metallurgically clean work-pieces within 3 to 10 min in circulating-type washing equipment.

Ipsen Compound 103 is a granular mixture of alkaline materials combining detergents and surfactants. According to the company, the cleaning action eliminates the need for secondary washing operations, or presoaking.

Due to its concentration, less than 1 oz of compound per gal of water is said to provide an efficient degreasing solution for either batch or spray type washers.

(Continued on page 150)

For more information, turn to Reader Service Card, Circle No. 467

New Materials, Parts and Finishes

Three New Coatings for Plastic Materials

Three series of basic coatings for plastics have been developed by the *Sullivan Chemicals Div.*, 420 N. Hart St., Chicago 22, Ill. One series is for application on articles fabricated of Royalite, styrene, acrylic and certain types of acetates. A second series is for application on molded polystyrene, and the third for the metallizing phase of plastic decorating. All three series can be pigmented or dyed to obtain the desired color tone.

Polyplex Series

According to the company, this series of coatings possesses maximum adhesion, flexibility, and hardness and will withstand vacuum forming after application to the plastic surface. When dried, the coating becomes an integral part of the base material. Under normal conditions it will dry rapidly and can be adjusted to spray gun application.

Plastiplex Series

This series, developed for application on general purpose molded polystyrene, high-impact polystyrene, and high-temp molded polystyrene, can be applied by hand spray, automatic spray or dip without crazing the base plastic, according to the company. The coatings are also said to possess high adhesion to phenolic or other thermoset materials.

Metalplex

These coatings are available for both first and second surface application. Only the base coat requires baking, which is done as a precaution to eliminate outgassing of latent solvents trapped in the coating.

Compound Strips Metal Coatings

A new stripper, Econostrip, for removing paint, lacquer, enamel and other finishes from various metals has been marketed by the *Beck Equipment Co.*, 3350 W. 137th St., Cleveland, Ill. The compound does not remove the bonderize or phosphate coating.

For use, it is reduced equal parts with water. The stripper swells and tack the metals themselves. It can be loosens the old finish which can then be rinsed off or cleaned by regular degreasing operations. According to the company, Econostrip will not attack the metals themselves. It can be

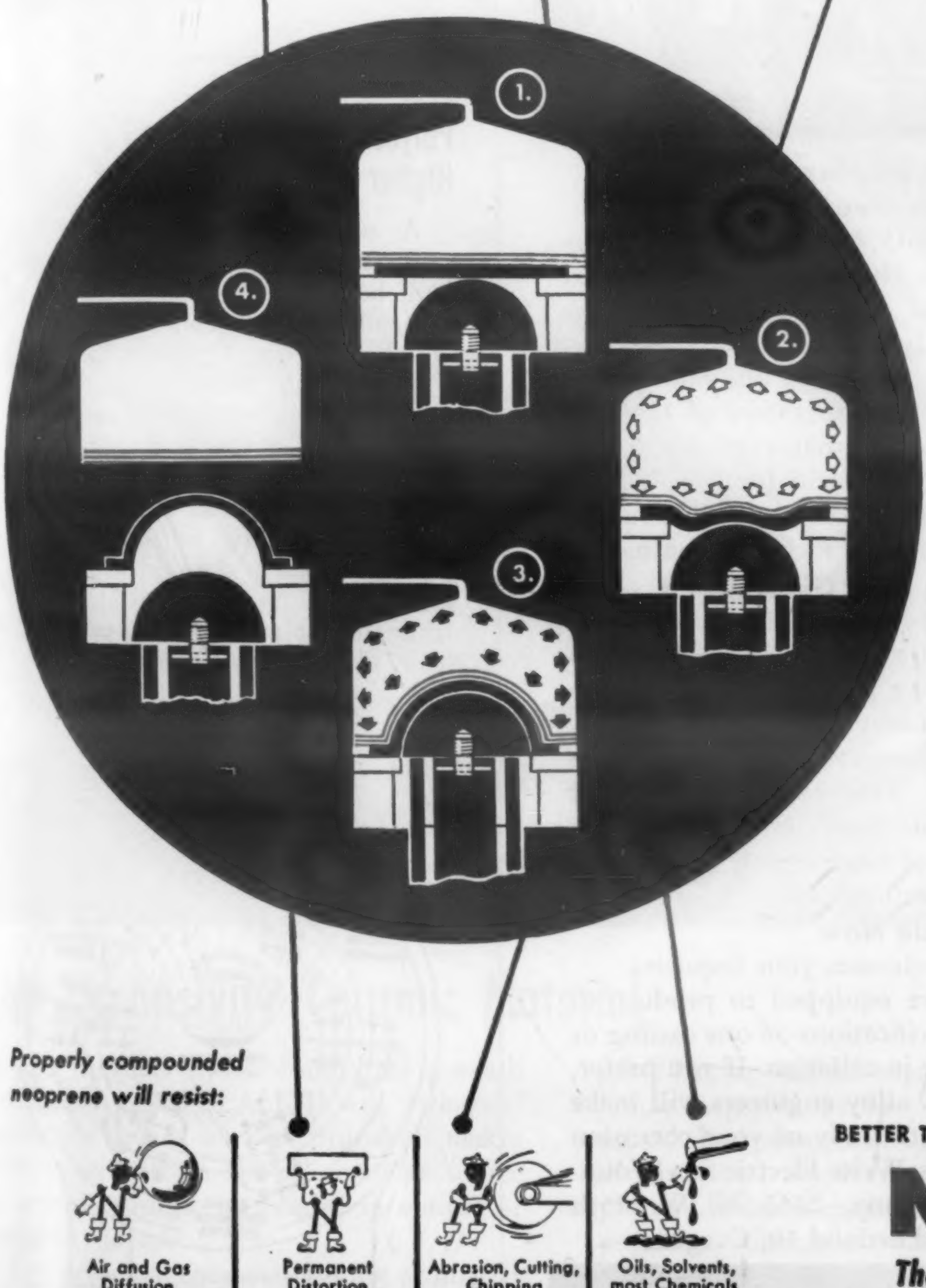
OIL RESISTANCE

ABRASION RESISTANCE

FLEXIBILITY

These properties of neoprene make a better

HYDROFORM MACHINE

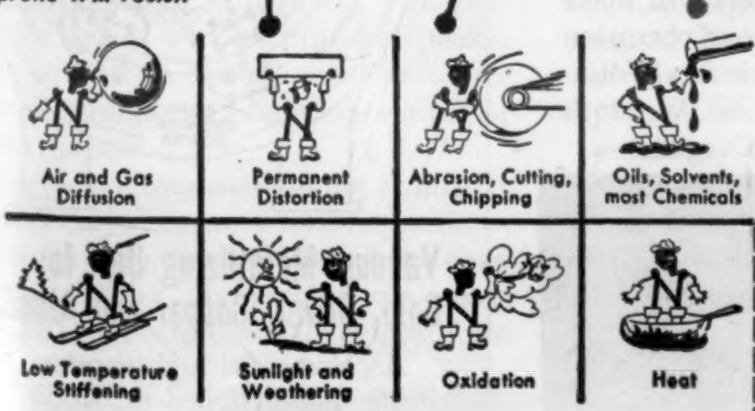


A recently developed method of fluid forming is employed in a new metal drawing machine which greatly simplifies production. It's known as "Hydroforming" and depends on a flexible neoprene diaphragm for its effectiveness. Under controlled conditions of pressure from the hydraulic oil in the head, the diaphragm acts as a universal female die . . . cuts die costs 50% or more.

In operation, a metal blank is placed on a draw ring and the upper forming cavity, faced with the neoprene diaphragm, is locked into position (Fig. 1). Hydraulic pressure is increased to a predetermined level—up to 8,000 psi for some metals (Fig. 2). The die punch is then forced up against the diaphragm into the forming cavity, and pressures up to 15,000 psi literally wrap the blank around the punch (Fig. 3). Pressures are then released, the forming cavity is raised, and the punch stripped from the finished part (Fig. 4).

Because of the even distribution of pressure, the draw is uniform with no thin-outs or spot stresses. And with every draw there's new proof of the remarkable resistance of neoprene to deterioration from oil and abrasion. Even after thousands of cycles the rugged diaphragms remain free from cracks . . . retain their resilience. Small wonder so many designers turn to Du Pont neoprene when it can stand up to a test like this!

Properly compounded neoprene will resist:



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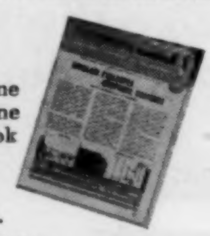
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

NEOPRENE

The rubber made by Du Pont since 1932

FREE! **THE NEOPRENE NOTEBOOK**



Each issue shows new, unusual applications of neoprene . . . new products . . . improved designs. The neoprene application cited above is covered in detail in Notebook No. 54. Add your name to the mailing list today.

E. I. du Pont de Nemours & Co. (Inc.)
Rubber Chemicals Division MM-3, Wilmington 98, Del.

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Firm______________________________

Address___________________________

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For more information, turn to Reader Service Card, Circle No. 361

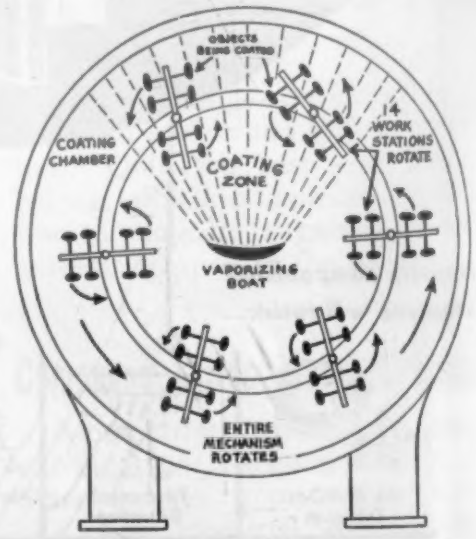
used either in a continuous production operation, or from a drum.

Although the manufacturer claims that the solution will last for long periods of time without weakening, the company provides a lower priced additive that will rebuild the solution when dragout lowers the concentration.

Polyester Resin Offers Higher Heat Resistance

A new polyester resin, AR493, said to possess increased chemical and heat resistance, has been developed by the *Chemical Div., General Electric Co.,* Pittsfield, Mass.

Glass cloth laminates made with the new resin will withstand maximum continuous operating temperatures up to 300 F; intermittent temperatures up to 480 F may be tolerated. According to the company, this development should contribute to the broadening of applications for laminated polyester resins, particularly in the electrical industry.



Vacuum Metallizing Unit for Gold, Silver, Copper and Aluminum

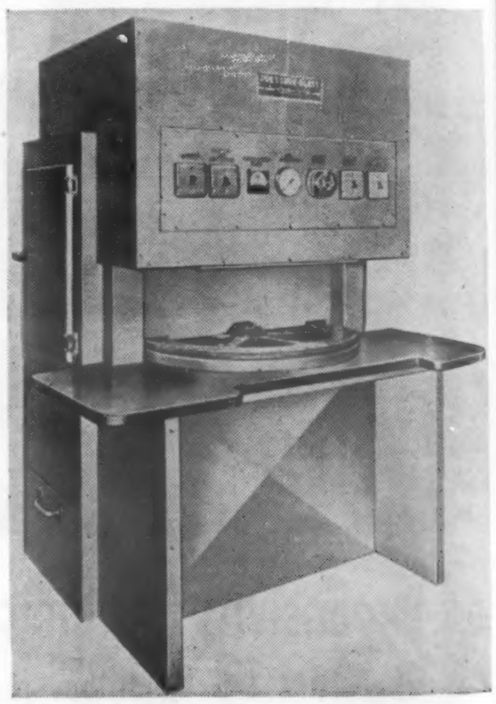
A commercial high vacuum metallizing unit designed to handle gold, silver, copper and aluminum coatings on an interchangeable production basis, has been marketed by the *High Vacuum Equipment Corp.,* Hingham, Mass.

The metal to be evaporated is

New Materials, Parts and Finishes

held in resistance-heated boats on the stationary rods running through the axis of the cylindrical chamber. The metal as it evaporates disperses upward through a 60 to 90 degree arc, and the rotating mechanism carries each piece through this arc, allowing the work to be completely coated. The work stations are also rotated on their own axes to insure complete coverage.

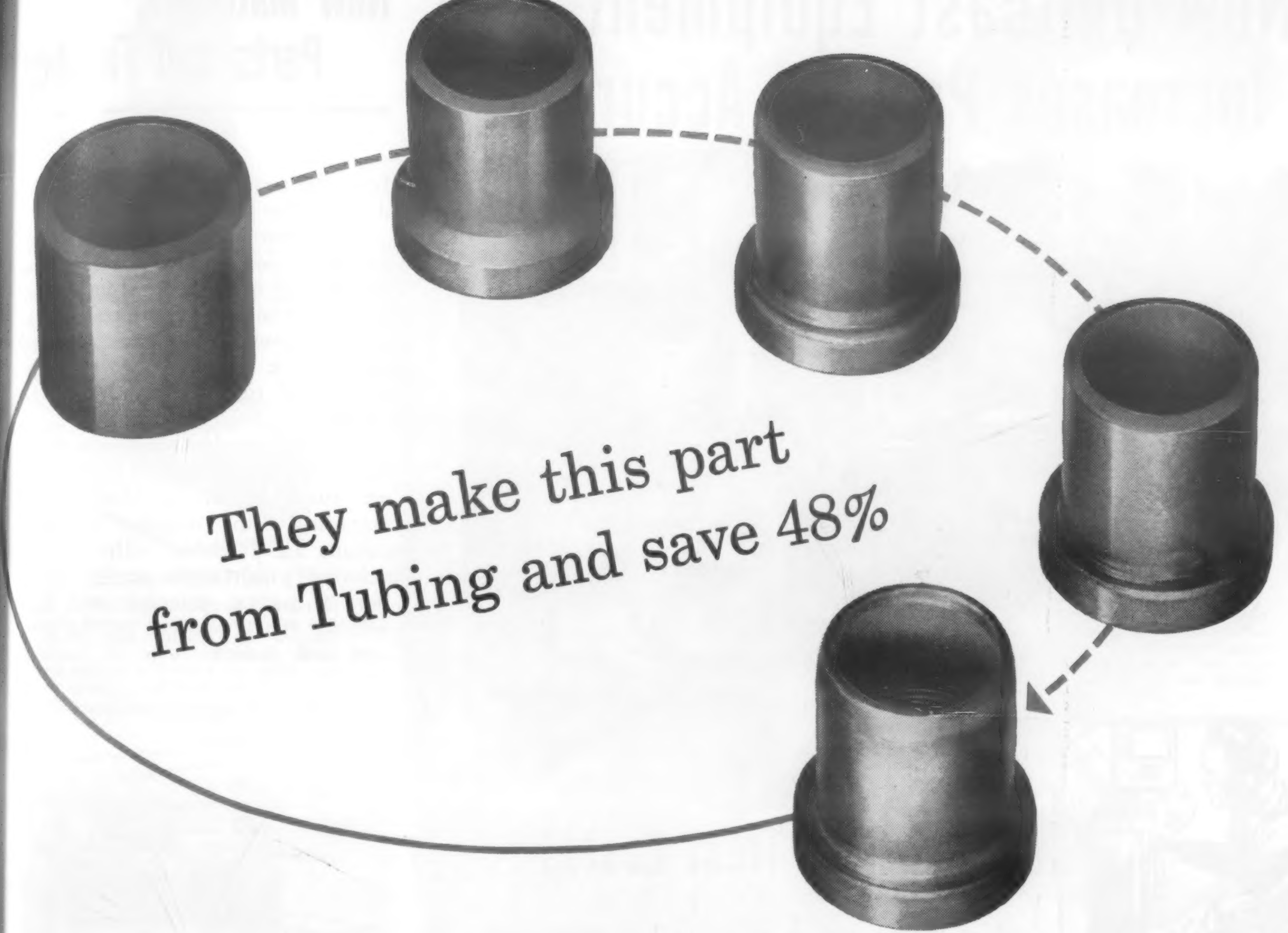
The test coils are wound for any size opening desired. Some of the typical parts tested with the instrument are cited by the company as bolts, nuts, roller bearings, jet engine rotors, blades and other forgings, malleable castings, welding rods, steel and copper tubes, piston rings, and barstock.



Rotary Wet-Blasting Machine Provides Automatic Operation

An automatic wet-blaster that blasts, rinses, and dries the workpieces has been developed by the *Cro-Plate Co., Inc.*, 747 Windsor St., Hartford 5, Conn.

In operation, the operator sits at the front of the Pressure Blast Roto-Matic machine loading and unloading the work-pieces from a rotating table having the appropriate work holding fixtures. The table carries the work first into the blast chamber, where fixed guns finished the workpiece; then into the rinse chamber where the abrasive slurry is rinsed



They make this part from Tubing and save 48%

This part used to be made out of solid bar stock on a screw machine. Costly? You bet. 12½ cents each. Lots of expensive machining. Lots of metal wasted to make a hole.

Now, Northwestern Corporation, Morris, Ill., makes it out of tubing. ELECTRUNITE Mechanical Tubing, 1½ O.D. x 11 gage. The customer gets it in 14-foot lengths, cuts it off into 2" lengths.

Next, the tubes are formed in a series of dies. Pretty drastic reductions, but the ELECTRUNITE Tubing can take it. Then they're machine finished in one operation.

The result: Each part now costs only 6½ cents. Multiply that by several million parts a year the manufacturer produces and you come up with a sizable saving.

Unusual, you say? Not at all. Republic has helped a lot of manufacturers cut costs drastically by helping them design with Republic ELECTRUNITE Tubing. A call to your nearest Republic Sales office will bring you all the facts.

REPUBLIC STEEL CORPORATION
Steel and Tubes Division
218 E. 131st Street, Cleveland 8, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, N. Y.

Republic
REPUBLIC STEEL
ELECTRUNITE TUBING

• For more information, turn to Reader Service Card, Circle No. 389

New Materials, Parts and Finishes

from the work; then through the air-dry chamber where they are dried.

Each chamber is accessible from all sides by means of inspection doors, and a panel in front of the operator contains all necessary controls for operation. A variable speed table drive regulator governs the amount of time the work is to be blasted.

Made of stainless steel throughout, no pumps or mechanisms of any kind are employed in the blast system, according to the company. Two blast circuits are available; either regular velocity, which works on the aspiration or suction principle and high velocity which operates on the pressure tank system.

Self-Contained Unit Aids Vacuum Forming of Plastics

A vacuum forming machine that requires no supplementary equipment has been marketed by *Pamco Industries, Inc.*, Ludlam Ave., Bayville, N. Y. The unit includes an air compressor and mold clamp frame assembly as well as a hydraulic pump.

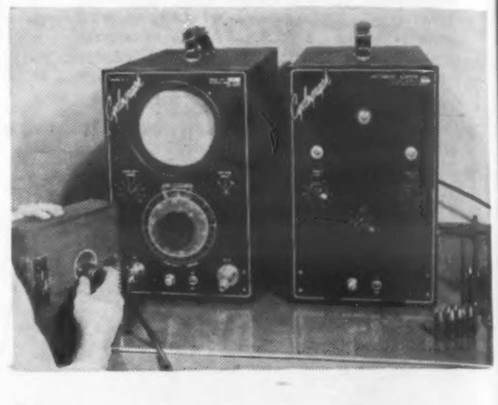
The Model HV-30-60 Pamco Hydro-Vacumatic can be operated automatically, semi-automatically, or manually, and the mold clamp frame is adjustable in all dimensions, allowing the use of molds of varying depths and sizes. The platen is 30 by 60 in. and allows the use of plastic sheets with a maximum size of 27 by 57 in. Other models are available with varying sized platens.

The Chromalox strip heater has three banks which can be operated

New Materials, Parts and Finishes

in any combination to provide temperatures ranging up to 1150 F; electrical requirements are 220 v, 60 cycle, 3 phase current. The single phase controller assembly is 110 v, 60 cycles. Timers provide a 60 sec scale, 1 sec calibration for the clamp, heater carriage, and vacuum valve.

The controls include a hydraulic gage, vacuum gage, solenoid valves wired with 4 delay timers, a microswitch assembly, and a West pyrometer.



Non-Destructive Testing Instrument; Automatic or Hand Operation

Non-destructive testing and sorting of mixed metal parts can be accomplished either automatically or by hand with the Model C-1 Cyclograph marketed by the *J. W. Dice Co.*, Englewood, N. J.

Manufactured under license from the A. B. DuMont Laboratories, the instrument can be used on either ferrous or non-ferrous metals, and will sort raw stock, semi-finished or finished parts by their metallurgical characteristics such as analysis, hardness, structure, case depth, etc. A known part is first accepted as standard, and the instrument is adjusted to suit it.

When sorting by hand, the operator watches the screen and manually removes rejects. For automatic operation, a Type 407 Automatic Relay Unit is used. The parts are then passed through the test coil on a belt conveyor or by other similar means. The Relay Unit sends out a signal whenever a sub-standard part passes through the coil and this signal can be used to operate a solenoid which, in turn, may operate some kind of rejecting mechanism.

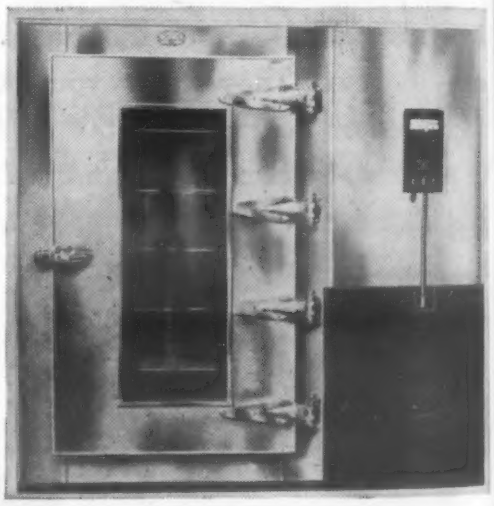
(Continued on page 160)

New Materials, Parts and Finishes

Drag Electrode for Mild Steel Weldments

A new electrode known as Airco Easyarc 12 has been developed for fast welding of mild steel involving plate and rolled sections by the Air Reduction Co., Inc., and is being marketed by the *Air Reduction Sales Co. Div.*, 60 E. 42nd St., New York 17.

The drag action of the electrode is obtained by adding powdered metal to the electrode coating, thereby allowing the rod to be dragged in contact with the plate. The metal powder becomes part of the weld bead, thus accounting for the faster welding, according to the company. The weld spatter is also said to be decreased.



Large Capacity Test Chamber

A test chamber designed for large capacity testing at high and low temperatures has been marketed by the *Webber Mfg. Co., Inc.*, 2740 Madison Ave., Indianapolis 3, Ind.

The Model A-30-40FH has a 30 cu ft capacity and operates over a temperature range of —40 F on refrigeration cycle, to 200 F on heating cycle. Other units are available with temperature ranges down to —200 F.

According to the company, features of the unit include visible type controller, patented heat exchangers, and multi-paned visual port and apertures for connections to inner chamber. The unit is of stainless steel construction with glass fiber insulation.

Contents Noted

A digest of papers, articles, reports and books of current interest to those in the materials field.

This Month:

- ***Russian Materials Developments***
- ***German Hot Work Steels***
- ***Reactor-Core Materials***
- ***Nickel-Free Steel Wire***

German Report on Hot Work Steels

German industrial recuperation since the war has aroused a great deal of respect both here and abroad, and of course, in political circles, a great deal of controversy. From the technical standpoint, however, it cannot be denied that the engineer, designer and industrialist can only benefit by keeping abreast of industrial developments in that country.

H. M. Hiller, in Vol 73, 1953, of *Stahl und Eisen,* reports on hot work steels in Germany, pointing out the standard alloys used and other grades that still require further work. Standard German hot work steels may be divided into 4 groups: tungsten-base, nickel-base, chromium-molybdenum and chromium-vanadium base, and straight chromium. The table gives the breakdown of these four groups by German designation, analysis, and most common use.

As you can see from this table, the tungsten-base steels comprise the most important group, although work in that country has indicated that no worthwhile improvement is gained by increasing the tungsten over about 10%. On the other hand, small vanadium or molybdenum additions are much more effective than large tungsten additions. Better hot hardness at the expense of toughness can be obtained by increasing the austenitizing temperature. The lower alloy grade steels can generally be cooled more drastically in service than the higher, and therefore work better at lower tool temperatures.

Nickel-base steels in Germany today are often chosen for dies subject to high compression stresses but only moderate temperatures. The older, high nickel, chromium-molybdenum-nickel steels have been modified by lowering the nickel content, and partially replacing molybdenum with vanadium. These modified steels have been found to be at least equal, and in some cases superior, to the original especially where hot hardness and resistance to softening are involved. Preheating was found to overcome failures resulting from poorer shock resistance up to about 750 F.

For some reason, little attention has been paid in Germany to hot work steels without nickel or tungsten. For instance, the chromium-molybdenum-vanadium grades are used rather infrequently considering their relatively good properties. The molybdenum-free vanadium hot work

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German Hot Work Steels

Designation	% C	% Mn	% Si	% Cr	% Mo	% Ni	% V	% W	Main use
65 WMo 34 8	0.63/0.68	0.25*	0.25*	3.5/4.0	0.80/0.90	**	0.60/0.80	8.0/9.0	Most highly stressed hot-working
30 WCo 36	0.27/0.32	0.20/0.40	0.15/0.30	2.2/2.5	—	—	0.20/0.30	8.0/9.0	Most highly stressed hot-working
30 WCrV 34 11	0.25/0.35	0.20/0.40	0.15/0.30	2.5/2.8	—	—	0.30/0.40	8.0/9.0	Highly stressed hot-working
36 WNiCr 18 18	0.32/0.39	0.40/0.60	0.20/0.40	0.80/1.1	—	3.3/3.7	0.10/0.20	5.0/5.5	Tube extrusion mandrels
30 WCrV 17 9	0.25/0.35	0.20/0.40	0.15/0.30	2.2/2.5	—	—	0.50/0.60	4.0/4.5	Highly stressed hot-working
30 WCrV 15	0.25/0.35	0.30/0.50	0.70/1.0	0.90/1.2	—	—	0.15/0.20	3.5/4.0	Moderately stressed hot-working
45 WCrV 7 7	0.40/0.50	0.20/0.40	0.80/1.0	1.5/1.8	—	—	0.15/0.25	1.7/2.0	Moderately stressed hot-working
55 WCrV 7	0.50/0.60	0.20/0.40	0.80/1.0	0.90/1.2	—	—	0.15/0.20	1.7/2.0	Moderately stressed hot-working
35 WCrV 7	0.30/0.40	0.20/0.40	0.80/1.0	0.90/1.2	—	—	0.15/0.20	1.7/2.0	Moderately stressed hot-working
45 CrVMoW 5 8	0.40/0.50	0.30/0.50	0.50/0.70	1.2/1.5	0.40/0.50	—	0.75/0.85	0.4/0.5	Moderately stressed hot-working
45 CrNiW 58 52	0.40/0.50	0.60/0.80	1.2/1.5	13.0/14.0	—	12.5/13.5	1.0/1.4	1.0/1.5	Extrusion-press dies
40 NiCrMo 15	0.37/0.44	0.30/0.50	0.15/0.30	1.1/1.4	0.15/0.25	3.5/4.0	—	—	Forging dies
30 CrNiMo 8	0.26/0.34	0.30/0.60	0.15/0.35	1.8/2.1	0.25/0.35	1.8/2.1	—	—	Extrusion-press dummy blocks
56 NiCrMoV 7	0.50/0.60	0.60/0.80	0.15/0.35	1.0/1.2	0.30/0.40	1.5/1.8	0.15/0.20	—	Moderately stressed hot-working
55 NiCrMoV 6	0.50/0.60	0.50/0.70	0.15/0.35	0.60/0.80	0.10/0.15	1.5/1.8	0.10/0.18	—	Moderately stressed hot-working
45 CrNi 6	0.40/0.50	0.60/0.80	0.15/0.35	1.2/1.5	—	1.1/1.4	—	—	Extrusion-press backer blocks
40 CrMoV 2 1	0.4*	0.4*	1.0*	5.6*	1.0*	—	0.5*	—	Extrusion-press and die casting dies
45 CrMoV 6 7	0.40/0.50	0.60/0.80	0.15/0.35	1.3/1.5	0.65/0.75	—	0.25/0.32	—	Extrusion-press container liners
30 CrMoV 9	0.26/0.34	0.40/0.70	0.15/0.35	2.2/2.5	0.15/0.20	—	0.10/0.15	—	Extrusion-press parts
40 CrMnMo 7	0.35/0.45	1.1/1.5	0.15/0.35	1.7/2.0	0.15/0.25	—	—	—	Header tools; container jackets
26 CrMo 7	0.22/0.30	0.50/0.70	0.15/0.25	1.5/1.8	0.20/0.25	—	—	—	Centrifugal casting molds
26 CrV 7	0.22/0.30	0.50/0.70	0.15/0.25	1.5/1.8	—	—	0.15/0.20	—	Centrifugal casting molds
50 CrV 4	0.47/0.55	0.80/1.1	0.15/0.35	0.90/1.2	—	—	0.07/0.12	—	Lightly stressed hot-working
61 CrSiV 5	0.57/0.65	0.60/0.90	0.70/1.0	1.05/1.3	—	—	0.07/0.12	—	Lightly stressed hot-working
210 Cr 46	2.0/2.25	0.20/0.40	0.25/0.40	11.0/12.0	—	—	—	—	Forging die blocks
20 Cr 52	0.17/0.22	0.20/0.40	0.30/0.50	12.5/13.5	—	—	—	—	Die casting dies
85 Cr 7	0.80/0.90	0.25/0.40	0.15/0.30	1.6/1.9	—	—	—	—	Rolls for hot rolling
53 MnSi 4	0.50/0.57	0.80/1.0	0.80/1.0	—	—	—	—	—	Rolls for hot rolling; dies

NOTES:
* *Typical.*
** *1.8/2.3% Co.*

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German Report on Hot Work Steels

continued

steels have proved satisfactory for lightly stressed tools, and the straight chromium grades have given good service in special cases.

Austenitic steels are used only for parts such as extrusion dies when the service temperatures are so high (over about 1200 F) that the usual martensitic grades are no longer adequate.

German work on the conservation of alloying elements seems to be especially valuable. In the field of moderately alloyed, hot work steels for the most severe service, more attention should be devoted to molybdenum steels, and further work should be done in increasing the molybdenum content. Efforts should also be made to decrease the temperature sensitivity of tungsten hot work steels without affecting hot hardness.

The effect of vanadium, which improves hot hardness but may lead to embrittlement, should be investigated more fundamentally, and the ultimate goal, Hillman points out, should be the development of moderately alloyed, general-purpose hot work steels with optimum properties, while decreasing the number of standard steels as much as possible.

High Soviet Claims for New Ceramic Material

A relatively new group of materials has been receiving more and more attention in the Russian technical press during the past year or two. Called microlites and designated as the Ts group, they are very dense and fine grained variants of corundum, a material made up for the most part of aluminum oxide.

Special attention has been given to TsM-332, for which remarkable properties have been claimed in such applications as high speed machining tools, dies, and watch parts, and in chemical plants owing to its high resistance to chemicals and heat. Prof. I. I. Kitaigorodski, leading Soviet authority on ceramics, described these uses for the new material in a Nov. 1953 issue of *Steklo i Keramika*. Articles previous to this have discussed the use of TsM-332 as indentors in high temperature hardness tests and, in addition, as tools for

Table 1

	Microlite	Hard alloy VK-8	Hard alloy T15K6	High speed cutting steel
Hardness, Rockwell A	92–93	88	90	83
Bending Str, kg/mm²	up to 45	130	110	370
Compression Str, kg/mm²	up to 500	350	400	380

Table 2

Material	Al_2O_3 in sintered product, %	Crystal size, mu	Volume wt, G/cm³	Hardness Rockwell A	Bend Strength, Kg/cm²	Compression Strength, Kg/cm²
Sinter-corundum	99.56	50	3.95	—	—	—
"Baked" corundum	100	20–30	—	—	up to 2600	30,000
Corund refractory	98.5–99	—	3.8	—	—	14,000
Thermo-corundum (VNIIASH*)	—	7–12	3.75	85	up to 2000	7000
Microlite	99.1	1–3	3.96	92–93	up to 4500	50,000

* *Research Institute for Abrasives and Grinding.*

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machining certain types of plastics.

For many applications it is often compared to the so-called hard metals, mostly known in Russia as the VK (tungsten carbide and cobalt) group, and with high speed tool steel. And in many applications it is claimed to be superior to these.

The development of the material, by Kitaigorodski and his co-workers in the Department of Glass and Ceramics Technology of the Moscow Chemical Technical Institute between 1948 and '51, was pushed because of the need for finding substitutes for critical hard materials such as commercial diamonds. Evidently the Russians now feel that they have found in the microlite TsM-332 a valuable addition to the growing list of corundum materials. These are usually based on the alpha form of aluminum oxide containing 99% oxide and 1% or less impurities. They are generally distinguished by high refractoriness, resistance to corrosion, great strength, and good dielectric properties.

The material seems to have a high density and very fine grain size. It is claimed that observation with optical and electron microscopes reveals a structure substantially different from that of other corundum materials, with close packing of extremely fine crystals that range in size from 1 to 3 microns. As the figures for bending strength in Table 1 show, the material is very brittle when compared to metal alloys, but Table 2 shows that even in bending strength, the material is superior to some other materials in the same class. The wear resistance and cutting properties of microlite are good, but owing to its brittleness it is best used for finish and semi-finish operations, where there is less risk of impact loads. Vibration, of course, must be kept to a minimum.

The material has now been tested in several Russian research laboratories and workshops, and reports generally agree that it has high wear resistance at high speeds—therefore long life, i.e., 350 min at 300 m per min. Some exceptional cases of long life and high speed are recorded, even up to 3200 or 3787 m per min, which is claimed to be a world record.

Other uses of the new material have been described, especially in high temperature work, such as dies for hot pressing non-ferrous metals, special bushings or linings exposed

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to great abrasive wear, bearings or supports for absorbing and transmitting forces at temperatures up to 1832 F, dies in wire and rope works and sand-blasting nozzles.

Russian Anti-Friction Materials

Carbo- or graphite-ceramics are becoming more and more widely used in various branches of machine construction due to their self-lubricating properties and others, the combination of which add up to longer machine life. The materials are usually produced by pressing and high temperature firing of carbon constituents obtained from a mixture of powdered petroleum or coke, for example, with graphite and carbon blacks.

In a study, the results of which are reported by I. V. Temkin in the Russian magazine *Vestn. Machin.*, Vol 33, 1953, materials of this kind which also contain metal powders are excluded, though the technique of manufacture of these materials is closely analogous to powder metallurgy.

If the firing or roasting of such materials is carried out at temperatures up to 1400 F, the product is mainly carbonized; but if the temperature is around 2600 F, then it is electro-graphitic with a pure carbon content of 98-99.8% and 2 to 0.2% ash. According to the composition of the initial batch (fineness of grinding and pressures and temperatures used) properties may be varied within wide limits for many different purposes or components in machine construction.

According to Temkin, the carbo-graphitic products may have the following general properties: 1) highly anti-friction: bearings are self-lubricating, and coefficient of dry friction with steel is 0.12 to 0.15; 2) small coefficient of linear expansion, e.g., 0.15×10^{-5}; 3) high mechanical stability, with a compression strength of 1400 kg per cm² or more; 4) good heat resistance, i.e., bearings can run at temperatures of 350-400 F in oxidizing atmosphere; and 5) good heat conduction and chemical resistance.

Wear on bearings made of the materials may be relatively heavy during run-in periods, but subse-

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quently declines to a minimum. This run-in period may be carried out with or without lubricants.

In Russia there now seems to be a wide range of these anti-friction materials to choose from. For instance, materials are available for use in bearings at speeds up to 1000 rpm for diameters up to 250 mm, and up to 4000 rpm for smaller diameters. Pressures up to 100 kg per cm² are used, while 50 kg per cm² seems to be about maximum for the smaller. The pressures, of course, decrease with speed.

Nickel-Free Steel Alloy for High Strength Wire

Although government controls of nickel have been off for some time now, the material is still a critical item and must be reserved for those uses where it is essential. Chromium too cannot be used unnecessarily. A light-weight communications cable, called the Spiral-Four, developed for the Army Signal Corps last year contains a braid made from 16 strands of cold-drawn Type 302 or 304 stainless steel wire. Since the stainless quality of these steels is not essential for this use, Battelle Memorial Institute was asked to develop an alternate nickel-less alloy for the chromium-nickel stainless used in the cable.

In the October, 1953 issue of *Wire and Wire Products,* an article based on a paper presented at the Annual Convention of The Wire Association by H. O. McIntire and G. K. Manning both of Battelle, described the development of the new alloy.

For an iron-based alloy to meet the magnetic requirements of the cable it had to be essentially austenitic, with drawability, strength, and electrical properties similar to those of Type 304 stainless. After narrowing down the type of alloys which might be usable to C-Mn-Fe, C-Cr-Mn-Fe, and Cr-Mn-Fe alloys with minor amounts of other elements such as carbon, nitrogen and copper, extensive testing was carried out to determine the optimum analysis.

An alloy was found meeting all the requirements, which though the total amount of alloys used was the same as in Type 304 stainless, substituted cheaper and more readily available manganese and copper for about 8% of the chromium and 9%

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of the nickel. It seems that further development work should be done, though they found that satisfactory results can be expected from alloys within the following percentage ranges: carbon, 0.08-0.15; chromium, 9.0-11.0; manganese, 14.5-18.5; silicon, 0.3-1.3; copper, 1.8-2.2; nitrogen, 0.08-0.15. Also, in order to conserve manganese it is desirable to keep the manganese near the low side of the range.

Typical properties of an alloy, the constituents of which fall within this established range were determined for an annealed wire with 93% reduction in area. They were reported to be as follows:

Tensile Strength,	292,500 psi
Tensile Yield Strength, 0.2% offset	282,000 psi
Ductility (alternate bend test)	315 deg
Electrical conductivity (% of standard copper)	2.2
Magnetism (Magne Gage Value)	0

Materials Problems in Reactor-Core Construction

The development of atomic energy has proceeded at a prodigious speed. In just 13 years we have progressed from the point where uranium, the basic fuel for reactors, was a laboratory curiosity to the threshold of commercial utilization of the power it generates. And the practical achievement of this goal depends to a great extent on the work of the materials engineer in developing new materials and learning more about little known properties of already existing materials to meet the exacting requirements of the atomic scientist.

In the January 1 issue of *Science*, H. A. Saller of Battelle Memorial Institute explains some of the problems in reactor-core construction and the metals which now seem to go far in the solution of these problems. He points out that uranium and thorium, the two main materials presently used as fuels for atomic piles, since they are neither corrosion resistant nor very strong, need other metals either as cladding or support. These metals, as well as needing the necessary structural requirements, must have a low thermal-neutron-absorption cross section, in order to mini-

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mize the loss of the neutrons emitted by the fuel, and therefore the resulting power.

The number of metals suitable for structural use in thermal reactors is severely limited, since only aluminum, beryllium, magnesium, and zirconium have thermal-neutron-capture cross sections of less than 0.5 barn per atom.* Beryllium has become well known for its toxicity and unexplained poor ductility. Its high melting point, low capture cross section (0.009 barn per atom), and good moderating qualities make it a promising reactor material. These are offset by poor ductility, erratic corrosion resistance, and health considerations.

Saller points out that at the present time, zirconium with its low thermal cross section (0.18 barn per atom), excellent corrosion resistance, good mechanical properties and fabricating qualities is the leading cladding and structural material for thermal reactors.

Moderating materials for reactors should be capable of reducing neutron energy rapidly, which requires a low atomic weight. The only good solid moderators are beryllium, beryllia, and graphite. In spite of many shortcomings it seems that beryllium and beryllia have in some cases been used as moderators, while graphite has found more widespread use because it is cheap, abundant, easy to work, and has good physical properties.

Reactor materials for control must possess high cross section for the absorption of neutrons. They should also have some strength, be fabricable, and have reasonable corrosion resistance in the reactor coolant. Boron and cadmium meet most of these requirements and have been used extensively. Hafnium, with its high cross section and metallurgical properties similar to zirconium should also make an excellent control material. Some of the rare earths have very high cross sections but have not been available in sufficient quantities. As they become available, Saller says, they will no doubt be used either alone or in alloys to greatly aid in the solution of these material problems unique to the atomic age.

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* A barn is a unit for measuring capture cross sections of elements. 1 barn = 10^{-24} cm^2 per neucleus.

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Books

WELDING ENGINEERING. *Boniface E. Rossi. McGraw-Hill Book Co., Inc., New York, N. Y., 1954. Cloth, 6 by 9 in. 786 pp Price, $8.00.* This text book is designed to familiarize the student with the fundamentals of welding and to provide a reference source for the engineer and designer seeking information on welding processes and applications.

It is divided into four sections. The first covers welding processes. Twelve chapters deal with such procedures as forge, gas, resistance and induction welding, soldering, brazing and the cutting of metals.

The second section deals with metals and their weldability. The metallurgy of welding is discussed after which the applications of the various welding methods to specific metals and alloys is taken up. Included are procedures for the welding of carbon and low alloy steels, stainless steels and clad steels; aluminum, copper, magnesium, nickel and their alloys; lead and zinc; and dissimilar metals.

Section three presents design and fabrication considerations in six chapters. These deal with field of application of welding design; types of joints, welds and stress distribution; layer sequences, deposition rates and welding costs; stresses in welded structures; welding jigs; and use of standard welding symbols.

Testing and inspection of welds is discussed in a fourth section. A series of five appendices cover welding terms and their definition; bibliography of welding; visual aids; questions and problems; and engineering data.

STATICS AND STRENGTH OF MATERIALS. *Roland H. Trathen. John Wiley & Sons, Inc., New York, N.Y., 1954. Cloth, 9 by 6 in. 506 pp. Price, $7.50.*

Written as a text for the engineering student, this book attempts to encompass the following objectives: presentation of the principles of statics and strength of materials and indication of the general methods of applying them to engineering problems; development of analytical ability by setting the engineering application in such a way that it presents a

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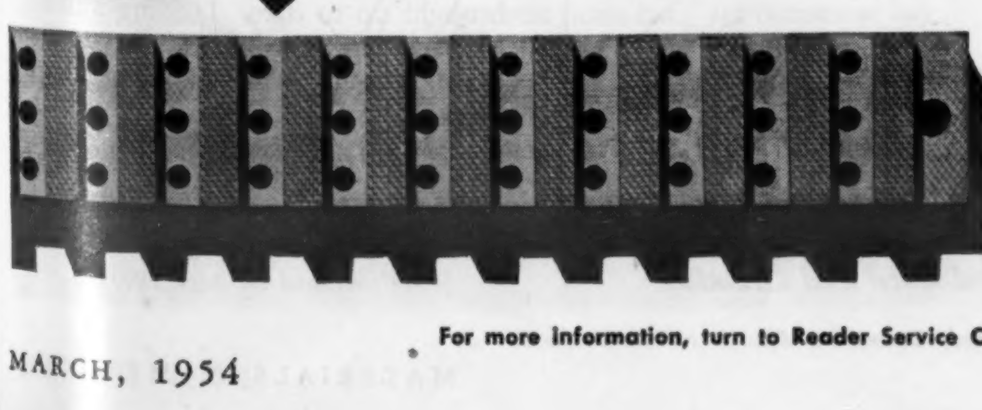
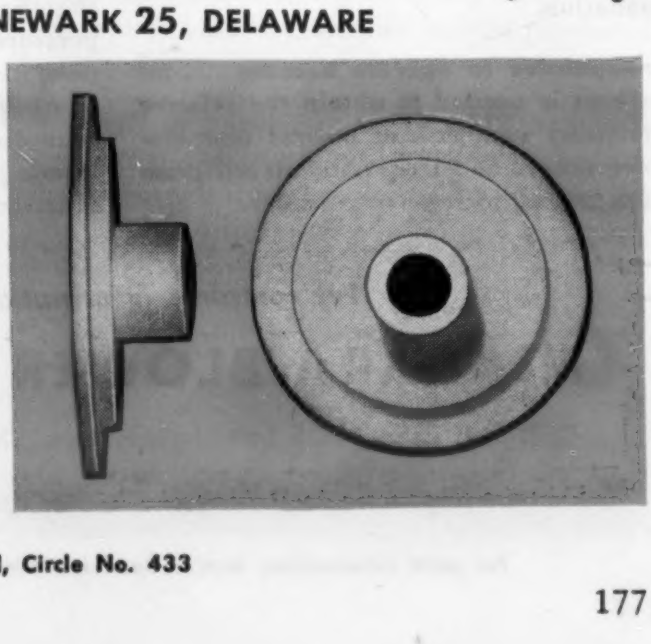
TERMINAL BLOCK—GB-28M. Sawed to shape, grooves milled, corners sanded round. Holes were drilled, counterbored, characters stamped. Machined by C-D-F.



INSULATOR — ML rod. Turned on automatic screw machine by C-D-F. Grade ML is a fine weave cotton fabric base laminate bonded with a melamine resin. Easy to machine.



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challenge in analysis; correlation of previous experiences in mathematics and physics with the discipline in mechanics; development of an appreciation of mechanics as a science. The author includes over 500 problems in his work as well as practice problems at the end of the book.

BUSINESS, LEGAL, AND ETHICAL PHASES OF ENGINEERING. *D. T. Canfield and J. H. Bowman. McGraw-Hill Book Co., Inc., New York, N. Y., 1954. Cloth, 9 by 6 in. 365 pp. Price, $6.00.*

This is the second edition of a book designed to help the student become aware of the managerial duties many engineers assume, as well as engineer-management contact and relations. Some of the changes include: material brought up to date and chapters on Accounting and Patents almost entirely rewritten; specialized and seldom used appendices deleted; two new chapters on Business Organizations and Stocks, Bonds and Notes; proprietorships, partnerships and corporations discussed. On the whole, this is a more general presentation than the first edition.

THE CONTROL OF QUALITY IN THE PRODUCTION OF WROUGHT NON-FERROUS METALS AND ALLOYS. I.—THE CONTROL OF QUALITY IN MELTING AND CASTING. *The Institute of Metals, London, England, 1953. Cloth, $8\frac{1}{2}$ by $11\frac{1}{2}$ in. 88 pp. Price, $2.50.*

Contained here are the papers presented at a Symposium held in London at the annual general meeting of the Institute of Metals with the discussion that followed.

MODERN USES OF NONFERROUS METALS. *Edited by C. H. Mathewson. Published by American Institute of Mining and Metallurgical Engineers, New York N. Y., 1953. Cloth, 5 by 8 in. 530 pp. Price: $7.00 to Nonmembers, $4.90 to Members.*

The Society through the Seeley W. Mudd Fund has published a second edition of *Modern Uses of Nonferrous Metals* to which new material has been added, and old material brought up to date. Leading authorities in their specific fields have written the 26 chapters. The general approach has been to include metals which have use as a basic material, while omitting those metals whose primary function is that of an additive.

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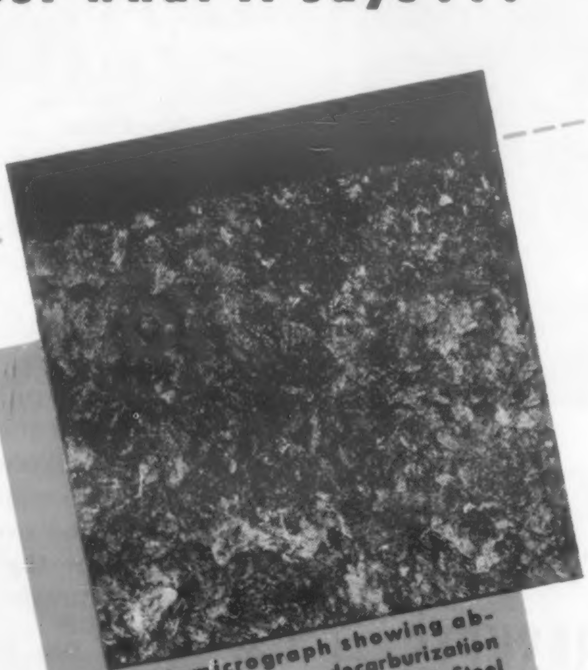
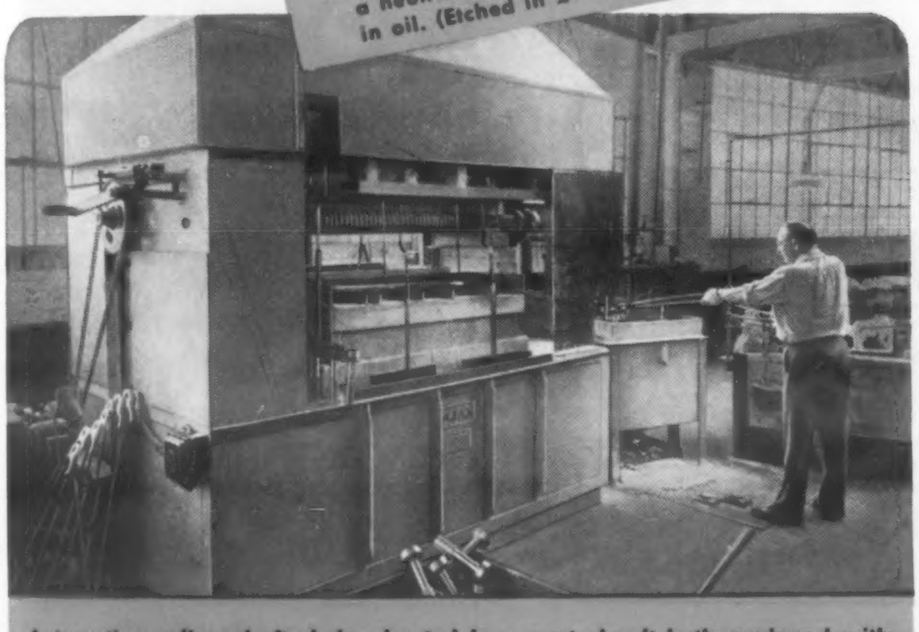
NEUTRAL HARDENING

means just what it says . . .

No Scale
No Decarb



Photomicrograph showing absence of scale or decarburization in a section of S.A.E. 1085 Steel (X100) hardened at 1500° F. in a neutral salt bath and quenched in oil. (Etched in 2% Nital.)



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A neutral salt bath provides an ideal means of heating carbon or alloy steel parts without any deleterious effect on the surface, such as scaling, pitting, carburizing or decarburizing. The bath completely seals out all air while work is heating . . . and a thin film of salt remains when work is removed, protecting it right up to the instant of quenching.

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Unique internal heating principle of the AJAX furnace—utilizing patented, closely-spaced, immersed electrodes—produces an automatic electrodynamic stirring action within the bath which contributes to faster heating of the work and assures a temperature variation of less than 5° F. throughout the bath.

This internal heating feature also permits use of long-lived ceramic pots, avoiding contamination of neutral baths by metallic oxides produced by metal pots.

The advantages of hardening in a neutral salt bath can be further enhanced by use of an isothermal salt bath quench (martempering or austempering) to hold distortion to a minimum and eliminate quench cracking.

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Contents Noted

Books continued

TEMPERATURE MEASUREMENT IN ENGINEERING, *Vol. 1. H. Dean Baker, E. A. Ryder and N. H. Baker. John Wiley & Sons, Inc., New York 16,, N. Y., 1953. Cloth, 6 by 9 in. 179 pp. Price: $3.75.*

Presented here in original and stimulating form are all the facts you need to design, construct and operate an effective temperature measurement installation. The book provides a list of the techniques to be employed, the proven methods of analysis, a survey of previous designs, the specific information required for feasibility of execution, and a well-developed procedure of general applicability. The work also includes a full listing of the various types of temperature-measuring instruments.

SYMPOSIUM ON FRETTING CORROSION. *American Society for Testing Materials, Philadelphia 3, Penna., 1953. Paper, 6 by 9 in. 88 pp. Price: $2.75; to ASTM Members, $2.00.*

The various papers in this symposium were discussed by experts in the fields concerned, and their comments have been included with the papers in this publication.

1953 SUPPLEMENT TO ATLAS OF ISOTHERMAL TRANSFORMATION DIAGRAMS. *Published by United States Steel Corp., Pittsburgh 30, Penna., 1953. Cloth, 5 by 8 in. 529 pp. No charge.*

Over four hundred isothermal transformation diagrams have been gathered together here from various sources in the United States, Great Britain and Canada. The compilation represents the majority of such diagrams available in the literature prior to 1952, plus several diagrams developed in United States Steel Corp.'s laboratories and not published in the 1951 edition.

Reports

FRICTION AND WEAR INVESTIGATION OF MOLYBDENUM DISULFIDE. 1—EFFECT OF MOISTURE. *Marshall B. Peterson and Robert L. Johnson, Dec. 1953. NACA TN 3055, 28 pp, diagrams, photos. Available from the National Advisory Committee for Aeronautics, 1724 F St., N. W., Wash. 25, D. C.* Reports the results of investigation of humidity effects of molybdenum disulfide lubricated steel surfaces.

(Continued on page 182)

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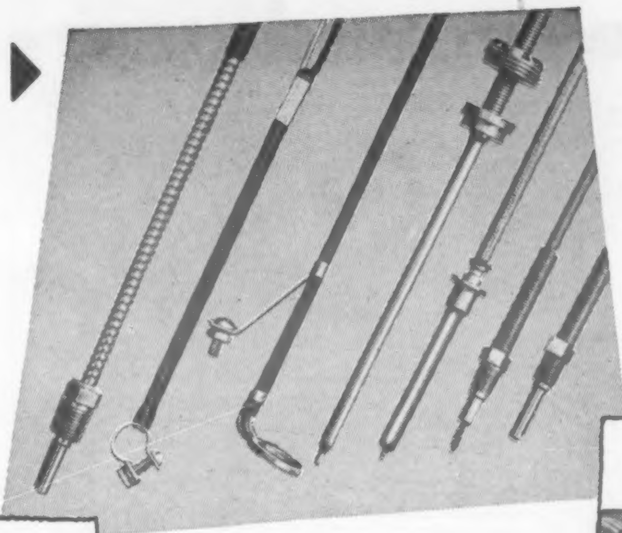

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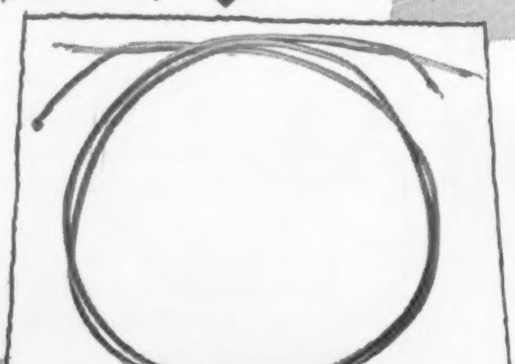

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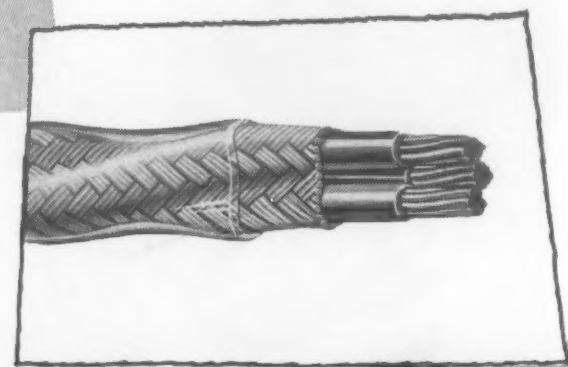

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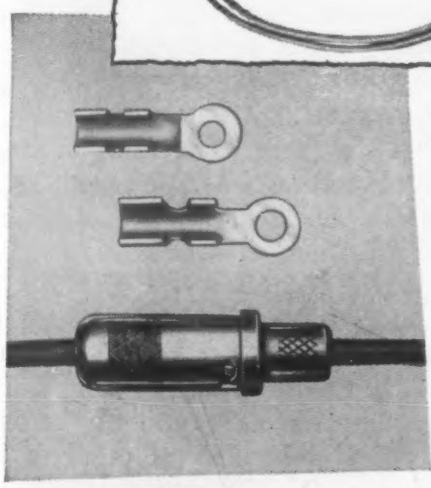

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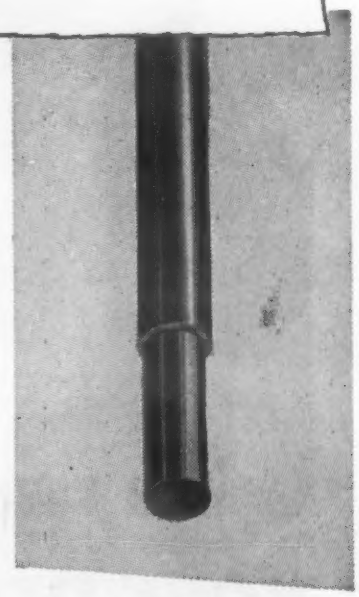

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Contents Noted

Reports continued

INVESTIGATION OF SANDWICH CONSTRUCTION UNDER LATERAL AND AXIAL LOADS. *Wilhelmina D. Kroll, Leonard Mordfin and William A. Garland, National Bureau of Standards, Dec. 1953. NACA TN 3090, 58 pp, diagrams, photos, 4 tables. Available from the National Advisory Committee for Aeronautics, 1724 F St., N. W., Wash. 25, D. C.* Reports the results of tests under combined axial load and lateral pressure to determine the strength of sandwich panels of various thicknesses. To compare results with computed values. Agreement between computed maximum loads and experimental failing loads within 9%.

POLYMETHYL METHACRYLATE (PERSPEX TYPE) PLASTICS; CRAZING, THERMAL AND MECHANICAL PROPERTIES. *H. Warburton Hall and E. W. Russell, Aeronautical Research Council (Gt. Brit.), 1953. ARC R & M 2764; ARC 12,829, 27 pp, diagrams, photos, 2 tables.* Report summarizes more practical results of a long-term investigation of the basic physical and chemical properties of the material. Thermal, elastic, crazing, solvent absorption, and mechanical properties are included, and the effect of these on the service efficiency of a plastic structure is described. Recommendations are included as to means of reducing or avoiding incidence of crazing due to tensile stress and absorbed solvent. Basic thermal properties are compared with those of metals and the dangers of differential expansion in combined metal-plastic structures are noted.

THE STOVE-ENAMELING OF ALUMINUM ALLOYS—EFFECTS ON TENSILE PROPERTIES. *Ministry of Supply (Gt. Brit.), Oct. 1953. MOS S & TM 3/53, 7 pp, diagrams.* Curves are presented showing the effects of a short period heating of aluminum alloys in the range of 248-392 F on the 0.1% proof and ultimate stress of the material. Further investigation was made on the possibility of recovery of properties taking place either by prolonging the low temperature stoving time or by leaving the material for long time at one temperature after stoving.

(Continued on page 184)

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Reports continued

DEVELOPMENTS CONCERNING AIRCRAFT GLASS FIBER PLASTIC LAMINATES. *Gail A. Clark, U. S. Air Force, Air Research and Development Command, Wright Air Development Center, Materials Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio, Jul. 1952. PB 112387, 176 pp, photos, diagrams, graphs, tables. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $6.50, photostat $22.50.* In particular the report describes developments and properties of heat resistant, polyester, silicone, and phenolic, laminates. Information on new sizings for glass fibers used in plastic laminates to produce improved strength polyesters, especially wet strength. Report covers progress on epoxide laminates, and mechanical properties of glass fiber base plastic laminates as effected by fatigue, preloading, direction of stress, construction and defects.

PROJECT TINKERTOY: MODULAR DESIGN OF ELECTRONICS AND MECHANIZED PRODUCTION OF ELECTRONICS. *U. S. National Bureau of Standards. Order separate volumes described below from Office of Technical Services, U. S. Dept. of Commerce, Wash. 25, D. C., giving PB number for each volume ordered.* VOLUME 1: PROJECT TINKERTOY: *Modular design of electronics and mechanized production of electronics, 1953. PB 111275. Mimeo: $2.00.* Summary description of MDE and MPE including background information, discussion of machines, concepts; includes up to 20 photographs and a select group of references of printed circuits and related subjects. VOLUME III: *Hand fabrication technique and photographic processing for modular design of electronics, 1953. PB 111277, 35 illus. Mimeo: $2.00.* Describes various operations associated with a model shop which are directly related to manual production of MDE.

BIBLIOGRAPHY ON HIGH FREQUENCY AND DIELECTRIC INDUCTION HEATING. *Compiled by the staff of Northwestern Technological Institute Library, Northwestern University, Evanston, Ill., Aug. 1946. PB 112327, 99 pp. Available with supplement from Northwestern University, Library, Evanston, Ill., $.65. Supplement available as PB 112327s 1949, 46 pp.* (Continued on page 186)

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Reports continued

BRAZING TITANIUM TO TITANIUM AND TO MILD AND STAINLESS STEELS. *W. J. Lewis, P. S. Rieppel, and C. B. Voldrich, Battelle Memorial Institute, Columbus, Ohio, Nov. 1952. PB 111244, 38 pp, photos, diagrams, tables. Available from Office of Technical Services, U. S. Dept. of Commerce, Wash. 25, D. C. Mimeo: $1.00.* Procedures and alloys suitable for brazing titanium were investigated. Report covers research during the year ending June 21, 1952.

DIRECTION FATIGUE TESTS WITH TENSILE AND COMPRESSIVE MEAN STRESSES ON 24S-T ALUMINUM PLAIN SPECIMENS AND SPECIMENS NOTCHED BY A DRILLED HOLE. *Gunnar Wallgren, Flygtekniska Forsoksanstalten (FFA), Stockholm, 1953. PB 112201, 30 pp, photos, drawings, diagrams, graphs, tables. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.00, photostat $3.75.*

DIELECTRIC CONSTANT AND DISSIPATION FACTOR OF SODA-POTASSIA-SILICA GLASSES AT FREQUENCIES OF 1 TO 300 KILOCYCLES AT ROOM TEMPERATURES. *George F. Stockdale, Illinois Engineering Experiment Station, Urbana, Ill., April 1953. PB 112184, 27 pp, drawings, diagrams, graphs, tables. Available from Engineering Experiment Station, University of Illinois, Urbana, Ill., $.30.* Report includes dielectric properties, electrical properties of glass, and capacity of bridges.

DATA ON THE COMPRESSIVE STRENGTH OF SKIN-STRINGER PANELS OF VARIOUS MATERIALS. *Norris F. Dow, William A. Hickman, and B. Walter Rosen, Langley Aeronautical Laboratory, Langley Field, Va., Jan. 1954. NACA TN 3064, 49 pp, diagrams, photo, 7 tables. Available from National Advisory Committee for Aeronautics 1724 F St., N. W., Wash. 25, D. C.* Flat skin-stringer compression panels of stainless steel, mild steel, titanium, copper, four aluminum alloys, and a magnesium alloy were tested. The results show the effect of variations in yield stress, Young's modulus, and both yield stress and Young's modulus for constant yield strain on the buckling and load-shortening of the panels.

(Continued on page 188)

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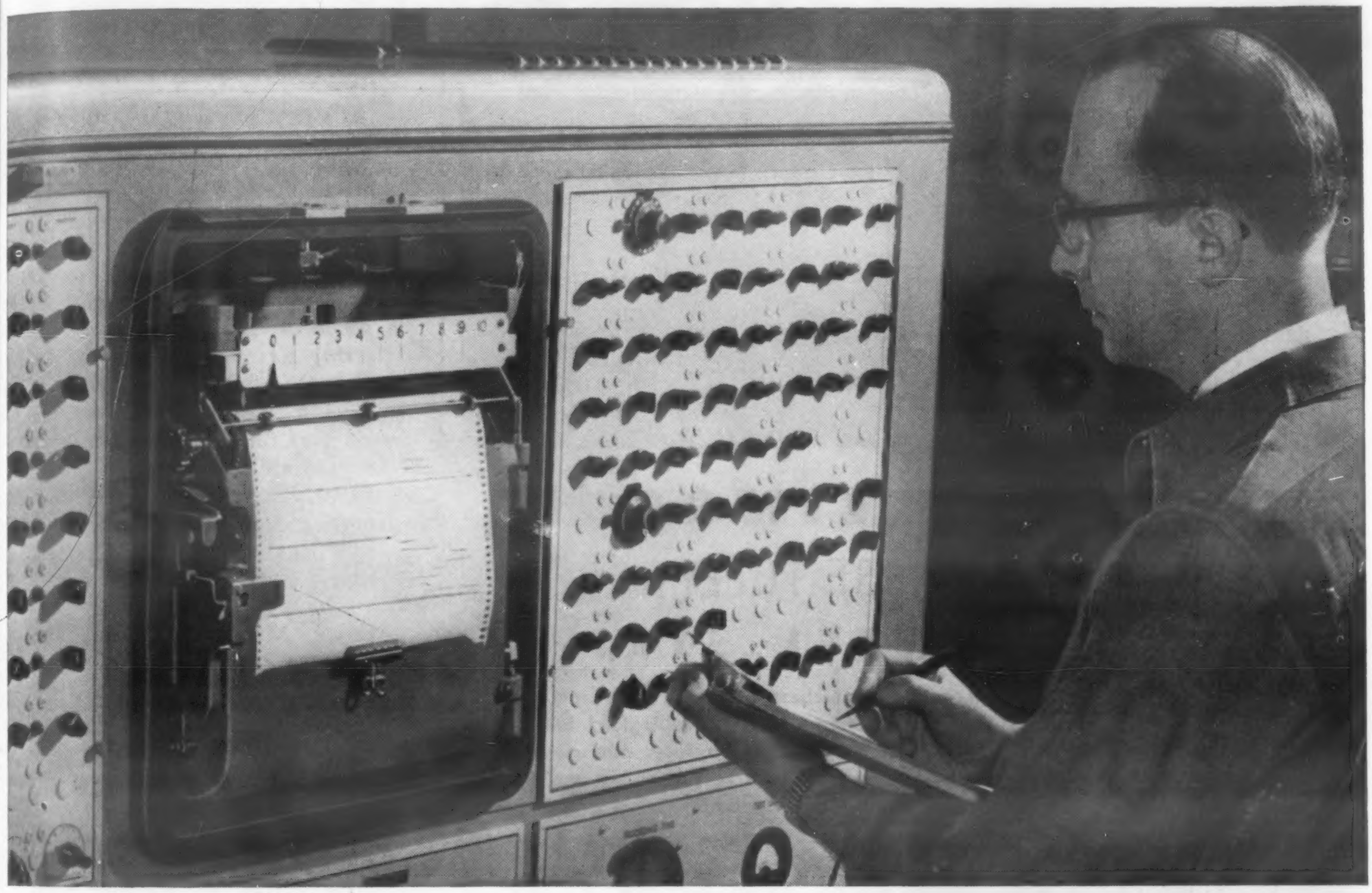

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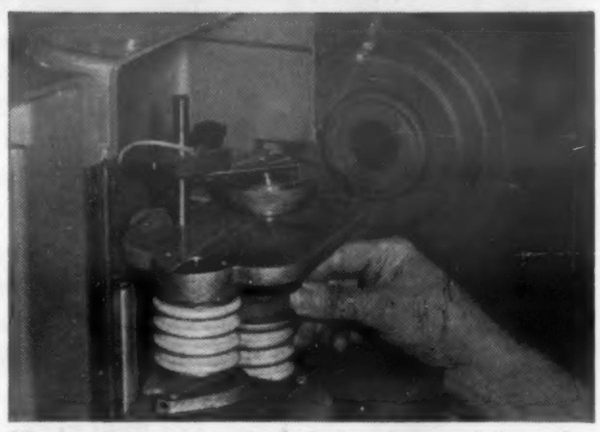

Here a brass sample is being inserted into the arc-spark stand of the Quantometer for analysis. In a matter of only 1½ minutes, sample will be completely analyzed.

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Cincinnati	Indianapolis	New Orleans	St. Louis	office only)

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Reports continued

LITERATURE REVIEW AND INDUSTRIAL SURVEY OF BRAZING. *By R. R. Banks, N. Bredzs, and John M. Parks, Armour Research Foundation, Chicago, Ill. June 1952. PB 112027. 193 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $7.00, Enlargement Print $26.25.* As well as a bibliography on brazing this survey includes brazing methods, fluxes, the design of joints and the metals used.

METAL-TO-CERAMIC SEALS. *By W. H. Christoffers, O. T. Purl, R. P. Wellinger, Illinois. Engineering Experiment Station, Electrical Engineering Research Laboratory, Electron Tube Section. April 1951. PB 109856. 25 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.00, Photostat $3.75.* Technical Report #5 covers ceramic to metal adhesives, vacuum furnaces, and design factors.

SOME MAGNETIC PROPERTIES OF FERRITE-PERMALLOY MIXTURES. *By Norman F. Hopson. June 1949. PB 110485. 57 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.75, Photostat $7.50.* Magnetic properties were determined for sintered mixtures containing 10-90% ferrite by weight. Optimum characteristics were obtained with a sample containing 70% Snock ferrite.

COEFFICIENT OF FRICTION AND DAMAGE TO CONTACT AREA DURING THE EARLY STAGES OF FRETTING. 1: GLASS, COPPER, OR STEEL AGAINST COPPER. *By Douglas Godfrey and John M. Bailey. U. S. National Advisory Committee for Aeronautics. Sept. 1953. TN 3011. 23 pp. Available from NACA, 1724 F St., N. W., Wash. 25, D. C.*

INVESTIGATION OF THE STATISTICAL NATURE OF THE FATIGUE OF METALS. *By G. E. Dieter and R. F. Mehl. U. S. National Advisory Committee for Aeronautics. Sept. 1953. TN 3019. 35 pp. Available from NACA, 1724 F St., N. W., Wash. 25, D. C.* This investigation concerned the fatigue properties of steels, aluminum, and various aluminum alloys.

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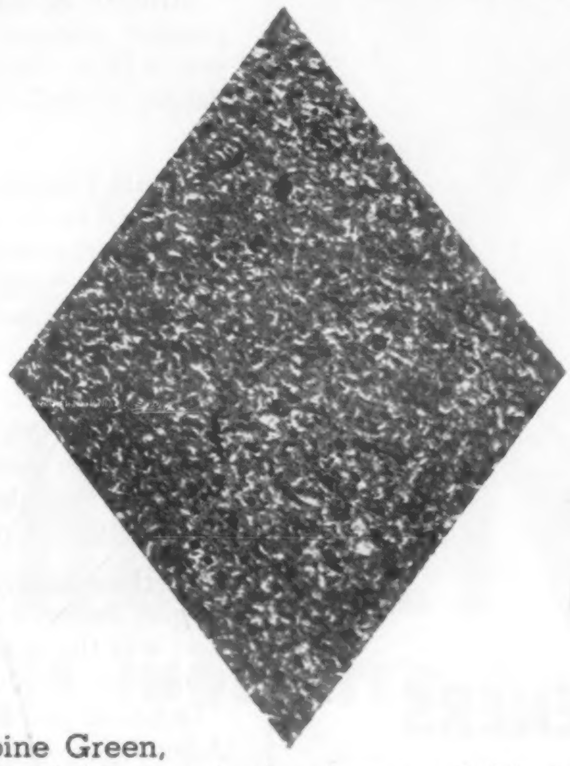

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news of ENGINEERS COMPANIES SOCIETIES

News of Engineers

Dr. Rush A. Lincoln has been named chief metallurgist, Allegheny Ludlum Steel Corp.

Charles A. Johnson has been named assistant director of research and development, Atlas Plywood Corp.

Robert A. Lubker has been appointed manager of the Metals Research Dept., Armour Research Foundation, Illinois Institute of Technology.

Leslie Clifton Whitney has been promoted to the position of manager, development engineering, Wire and Cable Div., Copperweld Steel Co. **Harry F. Zinsser** has been appointed chief metallurgist to succeed Mr. Whitney.

Evan W. McNeill has been appointed vice president in charge of the Ohio Seamless Tube Div., Copperweld Steel Co.

Arthur Stuart Laurenson, metallurgist, Belmont Smelting & Refining Co., was the winner of the 1953 International $2000 Contest devoted to "Technical and Research Aspects and Advantages of the Use of Lower Melting (Lower than Parent) Filler Metals in the Non-Fusion Welding Process", conducted by Eutectic Welding Alloys Corp. His paper was titled, *Tin Zinc Alloys for the Soldering of Aluminum.*

Raymond C. Firestone and **J. E. Trainer** were elected to the newly created positions of executive vice president, Firestone Tire & Rubber Co. Mr. Firestone has been vice president in charge of research and development since 1949 and Mr. Trainer has served as vice president in charge of production.

Rudolf Feldt has been named manager of the newly created Instrument Div., Federal Telecommunication Laboratories.

Charles Halcomb has been appointed permanent deputy director, Iron and Steel Div., Business and Defense Services Administration, U. S. Dept. of Commerce.

John T. Castles has been appointed manager—Technical Services

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news of | ENGINEERS

Unit, Marketing Section, Silicone Products Dept., General Electric Co.

S. B. Withington has been named president of the newly-consolidated Lycoming Div., Avco Manufacturing Corp. Appointment of other Lycoming Div. officers was also announced: **Floyd J. Bird,** vice president and plant manager; **Dr. Anselm Franz,** vice president, turbine engineering; **Arthur Nutt,** vice president engineering.

Dr. R. W. Sandelin has been appointed technical director, Alloy Metal Wire Co., division of H. K. Porter Co., Inc. Dr. Sandelin will head the metallurgical dept. and will be responsible for quality control.

George Sarvadi Jr. has been appointed design and development engineer, Falls Industries, Inc.

C. D. Tucker has been named production superintendent of the Bay City Div., Dow Chemical Co., with responsibilities for the magnesium foundry, magnesium fabrication and machine shop.

Eugene W. Caton has been appointed product development manager, Tubing and Extrusions, Boston Woven Hose & Rubber Co.

E. B. Conley has been appointed vice president and general manager of Allied Engineering Div., Allied International, Inc.

Dr. Adolph J. Lena has been appointed associate director of research, Allegheny Ludlum Steel Corp. in charge of the physical metallurgy section of the Research Dept.

Robert C. Anderson has been named assistant director of engineering for staff laboratories, Minnesota Mining & Manufacturing Co.

Charles W. Engelhard, chairman and general manager of the companies composing the Engelhard Industries Group, has relinquished his duties as president and **Gordon V. Richdale** has been elected to that position.

Douglas C. Albright has been named works manager, Coleman Co., Inc., to direct all phases of industrial engineering, production engineering, manufacturing and quality control in the Wichita factories of the company.

Edmond Charles Falleur has been named to the post of chief technical engineer, Belgian Electric Sales Corp.

news of | ENGINEERS

Vernon N. Ferguson, Temco Aircraft Corp.'s chief industrial engineer, has been promoted to the post of assistant factory manager at the Dallas Plant. **William N. Rathbun,** general supervisor of industrial engineering, succeeds Mr. Ferguson.

Latham E. Osborne, formerly executive vice president—defense products, has been appointed executive vice president and a member of the board of directors, Westinghouse Electric Corp. **Leslie E. Lynde,** vice president in charge of the Aviation Gas Turbine Div., will succeed Mr. Osborne.

William J. Miller has been appointed vice president, Catalin Corp., in charge of engineering at the company's Fords, N. J., Calumet City, Ill., and Thomasville, N. C. plants; **Kendal L. Briggs** has been named vice president in charge of production at the company's three plants.

C. P. **McHugh** has been named assistant director of research and product design at the Passaic, N. J. plant of Raybestos-Manhattan, Inc., Manhattan Rubber Div. **S. F. Horesta** succeeds Mr. McHugh as manager of the Roll and Tank Depts., and **E. D. Hines** has been named assistant manager.

Robert E. Morton has been named vice president and general manager of the Welding Div., Morton Manufacturing Co. Other appointments announced were: **James E. Morton,** vice president and assistant manager of the Welding Div.; **Jack E. Morton,** assistant secretary and purchasing agent; **Thomas H. Morton,** assistant treasurer and manager of the Machine Key Div.; **Oren G. Rutemiller,** manager of sales and engineering; **Sherwood Basch,** acting chief engineer; **Kenneth Oslund,** chief engineer, Welding Div.; **Harold Larsen,** production manager, Welding Div.

Glenn J. Gibson has been appointed to the engineering staff of Cooper Alloy Foundry Co. Mr. Gibson will direct a research program aimed at developing superior methods for the welding of corrosion and heat resistant alloys.

Robert H. Groman, divisional sales manager for Eutectic Welding Alloys Corp., has been promoted to the position of director of applied welding engineering.

P. S. Tseu has joined Pastushin

news of | ENGINEERS

Aviation Corp. as preliminary design aerodynamicist.

Adam B. Cribbs has been made manager for tool engineering and **James S. Nielsen** has been named manager for tool manufacture, Tool Div., Goodyear Aircraft Corp.

Frank J. Vette has been appointed assistant engineer, Adhesives and Coatings Div., Minnesota Mining & Manufacturing Co.

Clinton F. Robinson, president, Carborundum Co., has been named a director and president of Borolite Corp., a company recently formed by Firth Sterling Inc., American Electro Metal Corp. and Carborundum Co. **Kenneth D. Mann,** president of Firth Sterling Inc., and **Dr. Paul Schwarzkopf,** president of American Electro Metal Corp., were elected vice presidents and directors of Borolite.

Charles C. Smith has accepted the position of manager of operations, Roll Forming Corp.

James M. Lommel, graduate student in metallurgical engineering at Illinois Institute of Technology, has been awarded top honors by the American Institute of Mining and Metallurgical Engineers for a paper submitted to its twelfth annual contest. Title of the paper was *Isothermal Grain Growth in OFCH Copper.*

Dr. W. R. G. Baker, vice president and general manager of the Electronics Div., General Electric Co.; **Dr. Marvin J. Kelley,** president, Bell Telephone Labs.; and **Dr. Reinhold Rudenberg,** Gordon McKay professor of electrical engineering, Harvard, are three of the country's prominent electrical engineers who were recently inducted into Eminent Membership of the Eta Kappa Nu Association.

Thomas Hinchliff has been named project engineer, American Research Corp.

Helmut Thielsch has been appointed metallurgical engineer, Industrial Piping Div., Grinnell Co., Inc.

Wallace L. Howe was elected vice president in charge of research and development, Norton Co.

George Cory has been appointed to the position of senior design engineer, Associated Metal Fabricators, a division of Jersey Sheet Metal Products, Inc.

news of | ENGINEERS

R. B. Thompson has been named assistant general manager of manufacture for the American Can Co. **A. de Genaro**, formerly assistant manager of manufacture of the Atlantic Div., will succeed Mr. Thompson as division manager. Mr. de Genaro's previous position has been filled by **J. C. Souhan**, formerly manager of the company's Hillside, N. J. plant and more recently an assistant to the general manager of manufacture.

Howard R. Richards has been elected president and general manager, Industrial Ovens, Inc., and **A. V. Alexeff** has been named chief engineer.

B. M. Downey has been appointed manager of manufacturing, Shell Chemical Corp., and **A. W. Fleer** has been named manager of research, development and engineering.

D. A. Nabb has been named general manager of the Tube & Steel Div., Sharon Steel Corp.

John W. Juppenlatz, vice president of the recently formed Quaker Alloy Casting Co., was presented the Bradley Stoughton award for outstanding contributions to metallurgy by the Lehigh Valley Chapter of the American Society for Metals.

Harold C. Templeton has been made chief metallurgist, Lebanon Steel Foundry.

W. M. Trigg has been appointed manager of Westinghouse Electric Corp.'s new metals development plant which will be built at Blairsville, Penna.

Died..............**Stirling Murray Rust**, chairman of the board and a founder of the Rust Engineering Co.

....................**Dr. Karl B. McEachron**, General Electric Co. scientist, internationally known for his pioneering work on man-made lightning and high voltage phenomena.

....................**Robert S. Leather**, founder and chairman of the board, the Lea Manufacturing Co.

....................**George B. Hogaboom**, the American Electroplaters' Society's first president, founder and honorary member.

(Continued on page 198)

news of | COMPANIES

Lindberg Engineering Co. has announced the formation of EFCO-Lindberg Ltd., with headquarters at 544 Inspector St., Montreal, and branches throughout the Dominion. This company will combine the resources of Lindberg, Electric Furnace Co. of England and Williams & Wilson, Ltd. of Canada.

Reynolds Metals Co.'s new Robert P. Patterson aluminum reduction plant, located near Arkadelphia, Ark., is now in operation.

Koppers Co., Inc. has announced construction of a new mechanical development laboratory devoted to the refinement and adaptation of present products and processes plus the development of new products for the Metal Products Div. The new laboratory will be located at Koppers S. Baltimore Plant, one of the two large metalworking installations operated by the Division there.

Panellit, Inc. has begun construction on a new modern plant at 7401 Hamlin, Skokie, Ill., as the first step in a major expansion and consolidation program.

Standard Pressed Steel Co. has created a wholly owned subsidiary, Standco Canada, Ltd., with headquarters at 193 Bartley Drive, Toronto.

Resistoflex Corp. has placed in service a new pilot plant for the production of synthetic hose developed for the aircraft industry.

Scaife Co. has announced formation of a new corporation, Scaife Development Co., a fully owned subsidiary. The new organization is the exclusive licensing agent in the U. S. for an improved hot extrusion process.

Metal Hydrides, Inc. has announced formation of a new Metallurgical Development Dept. The new department will be headed by Emanuel Gordon, chief metallurgical engineer of the company.

Investment Casting Co. has moved into new quarters at 60 Brown Ave., Springfield, N. J.

Kennametal Inc. has announced it will construct a new manufacturing plant and office building to be located at 10201 Capital Ave., Oak Park, Mich. The plant will produce tungsten carbide tools and specialties, and is scheduled for completion on April 1.

(Continued on page 200)

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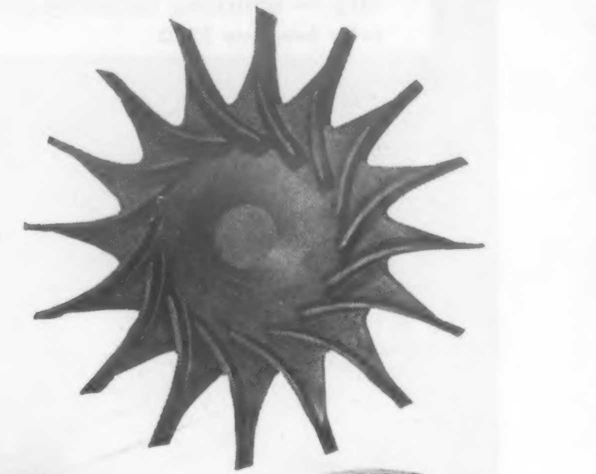

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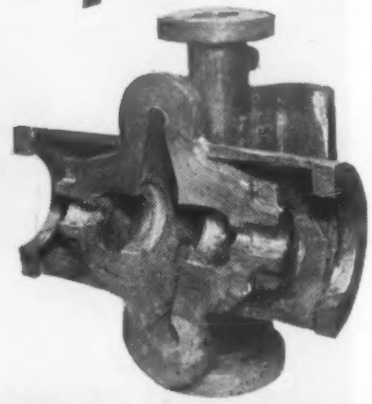

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news of | COMPANIES

General Electric Co.'s Silicone Products Dept. has announced the transfer of its Technical Service Unit from its Engineering Section to the Marketing Section.

Diamond Alkali Co. has announced formation of a Chlorinated Products Div., and a Plastics Div.

Detrex Corp. has announced completion of its new branch warehouse and office located in suburban Los Angeles.

Fabricon Products, Inc., Plastics Custom Molding Div., has completed its move to new quarters within its River Rouge plants.

Allis-Chalmers Manufacturing Co. has announced the completion of plans to enlarge the manufacturing facilities at its Terre Haute, Ind. works.

National Cylinder Gas Co. has simplified its corporate structure. Two of four wholly-owned subsidiaries now operate as divisions and the corporate charters of the remaining two have been surrendered and their operations taken over by the parent company. Tube Turns, Inc. has become Tube Turns Div. and Pennsylvania Forge Corp. of Philadelphia has become a division known as Pennsylvania Forge Co.; the Hollup Corp. of Chicago and National Cylinder Gas Co.—Pacific Coast, have been dissolved.

Pittsburgh Plate Glass Co. has announced that a 45-acre tract in Harmar Township, near Pittsburgh, has been purchased as the future site for a glass research laboratory.

Hercules Powder Co. disclosed its entry into the miracle fiber field as a major supplier of one of the key raw materials used by this industry, with the announcement of plans for a $4,000,000 plant at Burlington, N. J. The new plant will have a capacity of 12,000,000 pounds of dimethyl terephthalate (DMT) a year, for use in the manufacture of Terylene, British trade name for the polyester fiber developed in England. A similar product is known here as Dacron.

Richmond Structural Steel Co., Inc. will henceforth be known as Richmond Steel Co., Inc.

H. M. Harper Co. has moved to its newly-constructed, 15,000-sq ft building at 225 Hoyt Ave., Mamaroneck, N. Y.

(Continued on page 204)

For more information, Circle No. 508

For more information, turn to Reader Service Card, Circle No. 363

news of | COMPANIES

Coating Products Co. has moved to its new location at 101 W. Forest Ave., Englewood, N. J.

Carboloy Dept., **General Electric Co.**, has announced an expansion program of over $1,000,000 to be completed late in 1954. The program includes the addition of 36,000 sq ft of floor space to the department's metal building in Detroit, plus new engineering and manufacturing equipment.

E. I. du Pont de Nemours & Co., **Inc.** has announced a fund of $238,500 for grants to universities and colleges to advance the teachings of science.

The **Magnesium Co. of** America has purchased Tobey Manufacturing Corp., which will be operated as the Tobey Aluminum Div., MAGCOA, with Michael Neushul, its founder and president as vice president and manager of the division.

Vanadium Corp. of America has concentrated its research activities in a new research center at Cambridge, Ohio.

Link-Belt Co. has established a scholarship at Illinois Institute of Technology, to help a worthy student obtain an education in mechanical, metallurgical, or industrial engineering.

Quaker Alloy Casting Co., located at Myerstown, Penna., has been organized for the purpose of producing small carbon, low alloy, stainless and high alloy castings.

news of | SOCIETIES

Pressed Metal Institute has announced the election of Sam Morrison, president, Morrison Steel Products, Inc., as second vice president of the Institute.

National Association of Corrosion **Engineers** has announced the election of Kempton H. Roll, Lead Industries Assn., as chairman of the North East Region. Also elected to serve during 1954 were Edward G. Brink, American Viscose Corp. as vice chairman; Edwin J. Titsworth, Koppers Co., Inc., as secretary-treasurer.

The Institute of the Aeronautical Sciences has elected the following officers for 1954: John Leland Atwood, president and a director, North American Aviation, Inc., as president; William A. M. Burden, William A. M. Burden and Co., vice president; E. S.

news of | SOCIETIES

Thompson, manager, contracts, Aircraft Gas Turbine Div., General Electric Co., vice president; Edmund T. Price, president and general manager, Solar Aircraft Co., vice president; John W. Larson, chief engineer, Fort Worth Div., Consolidated Vultee Aircraft Corp., vice president, and Elmer A. Sperry, Jr., vice president and treasurer, Sperry Products, Inc., treasurer.

The **Committee on Vacuum Techniques** has announced that a High Vacuum Symposium will be held at the Berkeley Carteret Hotel at Asbury Park, N. J., June 16-18, 1954. Dr. K. C. D. Hickman, a pioneer who has received numerous patents in the field, will be honorary chairman of the Symposium.

The **Engineers Joint Council** has elected Dr. Thorndike Saville, dean of the College of Engineering, New York University, as president for 1954.

The **American Society of Tool Engineers** chartered its 112th chapter recently in Whiting, Indiana. The newest addition to ASTE is called the Calumet Area Chapter and comprises East Chicago, Gary, Hammond, Whiting and surrounding areas.

The **Cleveland Engineering Society** has announced plans for a new Engineering Center.

Industrial Furnace Manufacturers Assn., Inc. has elected L. H. Gillette, manager, industrial heating sales, Westinghouse Electric Corp., as president and director.

Ohio State University has named Professor Robert S. Green, chairman of the Department of Welding Engineering, as executive director of the university's Engineering Experiment Station.

The **Newcomen Medal**, given only three times before in the history of the U. S. branch of the **Newcomen Society**, was awarded recently to William H. Rowand, vice president, Babcock & Wilcox Co. at a joint meeting of the Society and the **Franklin Institute**.

The **American Institute of Chemists** has announced that Dr. William J. Sparks, co-inventor of butyl synthetic rubber, has been selected to receive the 1954 Gold Medal of the Institute. Dr. Sparks is director of the Chemical Div. and coordinator of Exploratory Research, Standard Oil Development Co.

(Continued on page 206)

Meetings and Expositions

SOCIETY OF AUTOMOTIVE ENGINEERS, production meeting. Chicago. March 29-31, 1954.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS, open hearth conference. Chicago. April 5-7, 1954.

INTERNATIONAL ACETYLENE ASSOCIATION, annual meeting. Chicago. April 7-9, 1954.

MALLEABLE FOUNDERS' SOCIETY, market development conference. Pittsburgh. April 8-9, 1954.

SOCIETY OF AUTOMOTIVE ENGINEERS, spring aeronautical meeting. New York. April 12-15, 1954.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, spring meeting. Cincinnati. April 14-16, 1954.

AMERICAN ZINC INSTITUTE, annual meeting. St. Louis. April 20-21, 1954.

METAL POWDER ASSOCIATION, annual meeting. Chicago. April 26-28, 1954.

AMERICAN SOCIETY OF TOOL ENGINEERS, industrial exposition. Philadelphia. April 26-30, 1954.

ELECTROCHEMICAL SOCIETY, spring meeting. Chicago. May 2-6, 1954.

AMERICAN WELDING SOCIETY, exposition and national spring technical meeting. Buffalo. May 4-7, 1954.

AMERICAN FOUNDRYMEN'S SOCIETY, annual convention. Cleveland. May 8-14, 1954

PORCELAIN ENAMEL INSTITUTE, midyear divisional meeting. Chicago. May 12-14, 1954.

INDUSTRIAL FURNACE MANUFACTURERS ASSOCIATION, spring meeting. Hot Springs. May 16-19, 1954.

BASIC MATERIALS EXPOSITION AND CONFERENCE, Chicago, May 17-20, 1954.

COPPER AND BRASS RESEARCH ASSOCIATION, annual meeting. Hot Springs. May 23-26, 1954.

AMERICAN IRON & STEEL INSTITUTE, general meeting. New York. May 26-27, 1954.

SOCIETY OF AUTOMOTIVE ENGINEERS, summer meeting. Atlantic City. June 6-11, 1954.

THE SOCIETY OF THE PLASTIC INDUSTRY, national plastics exposition. Cleveland. June 7-10, 1954.

AMERICAN SOCIETY FOR QUALITY CONTROL, national convention. St. Louis. June 9-11, 1954.

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News Digest

Plastics Meetings . . .

continued from page 6

J. Martin and Raymond L. Hunter, of the Boeing Airplane Co. Citing the increase in power capacity of today's aircraft electrical systems, he asserted that traditional phenolic insulating materials were no longer adequate. He backed this up with a motion picture film of actual arcing tests not only on phenolics but on other plastics and nonmetallic materials. The results indicated that some serious development work is needed to overcome this problem.

Another problem of particular importance in military aircraft is stress or stress-solvent crazing of the transparent acrylics used in canopies. It has been found that multiaxial stretching of some of these materials results in structures much more resistant to crazing, and development programs that would exploit this characteristic are reported underway. Dr. Irvin Wolock, of the National Bureau of Standards, discussed the results achieved by multiaxial stretching of several new plastics of both the methacrylate and alpha-chloroactylate types. Interest in the new materials is due to their superior heat resistance. All responded to the stretching and annealing treatments, with the alpha-chloroacrylates requiring annealing temperatures of about 230 F compared to 95-210 F for the methacrylates.

Modified Styrenes

Leading off the SPE conference was a symposium on modified styrenes. Representatives of five materials-producing companies discussed recent developments in rubber-modified styrene molding compounds and sheet for vacuum forming and outlined the growth of applications for these medium- and high-impact materials. Data on the use of acrylonitrile copolymer blends in pipe and fittings were also presented. A final paper covered present and potential applications for the more recently developed heat resistant modified styrenes.

The Reinforced Plastics Division started off its conference with a "government agency forum" in which representatives of various government departments reviewed recent devlopments in the field. Scientific developments and new applications shared the spotlight.

(Continued on page 212)

News Digest

In one of the most significant papers, a group of Naval Ordnance Laboratory scientists showed how variations in layup, molding processes and test methods produce wide variations in measured strength and elasticity of reinforced plastic panels. H. A. Perry, Jr., I. Silver, D. Peugh and F. R. Barnet feel that much present data on resins and finishes may be unreliable for comparison because of lack of standardization of these techniques, and they urged the industry to undertake such standardization.

Glass Finishes

In another paper, Perry and Silver joined with P. Erickson and H. E. Mathews, Jr. to discuss the results obtained with a new chlorosilane glass finish synthesized by the NOL. They found it definitely superior to the best commercial finishes tested for use with epoxy and phenolic resins, but the Bjorksten finish still seems to be superior for use with polyester resins. A current objective is to develop one finish suitable for use with all important laminating resins.

Later, the conference heard of several other new developments in glass-resin bonding. The most revolutionary approach was described by J. H. Plummer and C. F. Neumeyer, of Glass Fibers Inc. Glass rovings are difficult to size during production. Therefore a method has been developed in which the coupling agent, vinylethoxysilane, is added to the polyester resin rather than directly to the glass fibers. Provided the amount of lubricant and sizing used in the production of the rovings is held to a minimum it is possible to obtain laminates having wet strengths equivalent to those obtained when the glass is treated directly. Equally important was the discovery by J. D. Robinson, of The Englander Co., and James W. Case, of the Bureau of Ordnance, that increases in flexural strength of laminates as much as 100% could be achieved simply by improving the adhesion between glass fibers and the adjacent plastic. This was done by treating the glass fibers as they were freshly formed and in a nascent state of reactivity.

Compressibility of glass-reinforced laminates was investigated by N. Fried, A. Senstrom and R. R. Winans, of the New York Naval Shipyard's Material Laboratory. They found that compressibility does not

News Digest

vary appreciably with the rate of load application and that percent compressibility is not affected by the number of plies in the layup. The materials are more compressible wet than dry. Compressibility of mat, wet or dry, increases as dwell time of the load increases, but compressibility of glass cloth material is apparently unaffected by load dwell time.

Foamed Plastics

Although foamed plastics are not to be confused with reinforced plastics, they are often used with reinforced plastics in aircraft applications, and the complete sandwich can properly be considered an engineering material in its own right. Howard R. Moore, of the U. S. Naval Air Development Center, gave details of a new low temperature process for alkyd diisocyanate foams. Temperature control is achieved by direct addition of dry ice to the foam batter, rather than by outside water circulation. Removal of large quantities of exothermic heat before pouring results in more advantageous cross-linking which, in turn, produces good texture, better physical properties and better adhesion.

According to Jay M. Stevens, the Navy Bureau of Aeronautics is investigating the production feasibility of a wing of foamed-in-place plastic encased in a reinforced plastic skin. It is also trying to develop a foam core material suitable for helicopter rotor blades. Together with the Air Force, the Bureau is putting emphasis on the development of heat-resistant foams suitable for use at 500 F and above.

The foamed-in-place technique does not always work out. K. Telford Marshall, of the Transportation Research and Development Station, reported that paper honeycomb sandwich construction had proved more feasible in the construction of a 50-ft self-propelled barge. Another indication of continued armed services interest in plastic boats was a progress report delivered by W. R. Graner and J. B. Alfers of the Navy Bureau of Ships. Navy experience indicates that the first cost of plastic boats is definitely higher than that of wooden boats, and weight runs about the same or slightly lower. It is expected that both cost and weight can be reduced with further experience. Lack of design information has been a

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serious hindrance in the development of boats as well as shipboard storage tanks.

New Polyesters

A variety of new polyester resins were described at the conference. Most were designed for improved fabricating, particularly matched metal die molding. Emphasis on improved light resistance and fire resistance was also evident.

The exhibit held in conjunction with the reinforced plastics conference was not markedly different from last year's Washington show. However, there was evidence of increasing application of "extruded" shapes and of premix moldings, as well as increasing interest in pressure vessel applications.

The reports of the standards committee were received with mixed emotions by conference members. In many quarters there was a noticeable lack of interest. On the other hand, reports adding up to "no progress" caused some dissatisfaction among members who feel standardization is essential to continued progress of the reinforced plastics industry.

Flat Sheet Standards

Two proposed standards on flat sheet were submitted. The proposed standard for structural flat sheet establishes three grades having flexural strengths of 10,000, 20,000 and 30,00 psi, respectively. The proposed standard for electrical flat sheet establishes thicknesses and tolerances, as well as minimum standards of flexural strength, impact strength, dielectric strength, arc resistance and bonding strength.

Five other committees reported they were taking the first steps toward establishing definite standards. These were committees on premix molding, pipe, chemical resistance applications, housings and appliances, and corrugated sheeting. The preform committee continues to confine its activities to exchanges of information, believing that standards are not yet practical. The containers committee is currently attempting to determine whether standards are needed in that field.

No progress at all was reported on decorative laminates, rod and boats. I. M. Scott, of Winner Mfg. Co., recommended that the attempt to establish standards for commercial

plastic boats be abandoned. The most disappointing "no progress" report was turned in by Billy B. Curl, of Flexfirm Products, who announced that not a single written comment on the partial standard on nomenclature had been received. The partial standard covers definitions of product defects.

Plastics Engineering Curriculum Urged

How much need is there for plastics engineers, and what is being done about it?

These are questions that must be answered before an intelligent program for plastics education can be developed. The Society of Plastics Engineers has been busy getting answers to these questions for several years. At the annual meeting in Toronto in January, its Education Committee revealed the latest information.

In a survey which brought replies from an estimated one-fifth of this country's plastics engineers in diversified industries, Robert C. Bartlett of Natvar Corp. found overwhelming support for a program of plastics engineering education on a college level. Strong support was given to the SPE plan for a graduate curriculum leading to an M.S. degree in plastics engineering. In general, industry did not appear to be satisfied with the on-the-job training of their engineers, nor, probably, with its cost.

Today's Training

Judging from the survey, today's plastics engineer should have an educational background with most emphasis on chemical engineering and mechanical engineering, with complementary training in chemistry and electrical engineering. He is most likely to be employed in industrial design or development, with technical sales and service next in order of frequency.

Against this background of broad interest on the part of industry, C. C. Winding of Cornell University cited figures that showed little if any increase over the past two years in the

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number of colleges offering substantial work in high polymers.

According to Winding, only two universities are attempting to train men for work on polymeric materials. His survey shows a total of four schools offering 20 or more credits, five offering 10 to 20 credits and nine offering 5 to 10 credits. If the demand warrants it, Winding decided, there are about a half dozen universities "prepared to give engineers enough additional courses at the graduate level to train them for work on polymeric materials".

The condition of "demand" is an important one. Student demand, according to Winding, does not seem to be very great.

The Fifth Year

Whether the existence of plastics engineering curricula on a fifth year level will stimulate student demand sufficiently appears to be a serious question in the minds of some SPE members. H. A. Gadd, of Canadian General Electric Co., is one of many who favor an undergraduate curriculum and believe that it will be easier to get students interested in plastics engineering at that level than to persuade them to take an extra year of study.

The fact is, however, that most engineering colleges oppose any further specialization on the undergraduate level. If only for this reason, the fifth year plan seems to be a more practical objective than an under-graduate curriculum. A possible program that would follow an undergraduate curriculum in chemical engineering and lead to a professional degree in plastics enginering was outlined by Dean J. H. Lampe of North Carolina State College as follows:

Subject	*Credits*
Technology of Plastics	3
Plastics Laboratory	3
Chemistry of High Polymers	3
Properties of Plastics	3
Dielectrics and Insulating Materials	3
Chemical Engineering of Synthetic resins	6
Plastics Engineering and Design	3
Electives	6
Total	30

(Continued on page 222)

News Digest

Plastic Airplanes . . .

continued from page 7

Edger. Unattended, portable device machines thicknesses on compound curves or straight panels.

Metal sprayed mold for part of reinforced plastic aircraft fuselage section takes place of dies and fixtures required for metal semi-monocoque part.

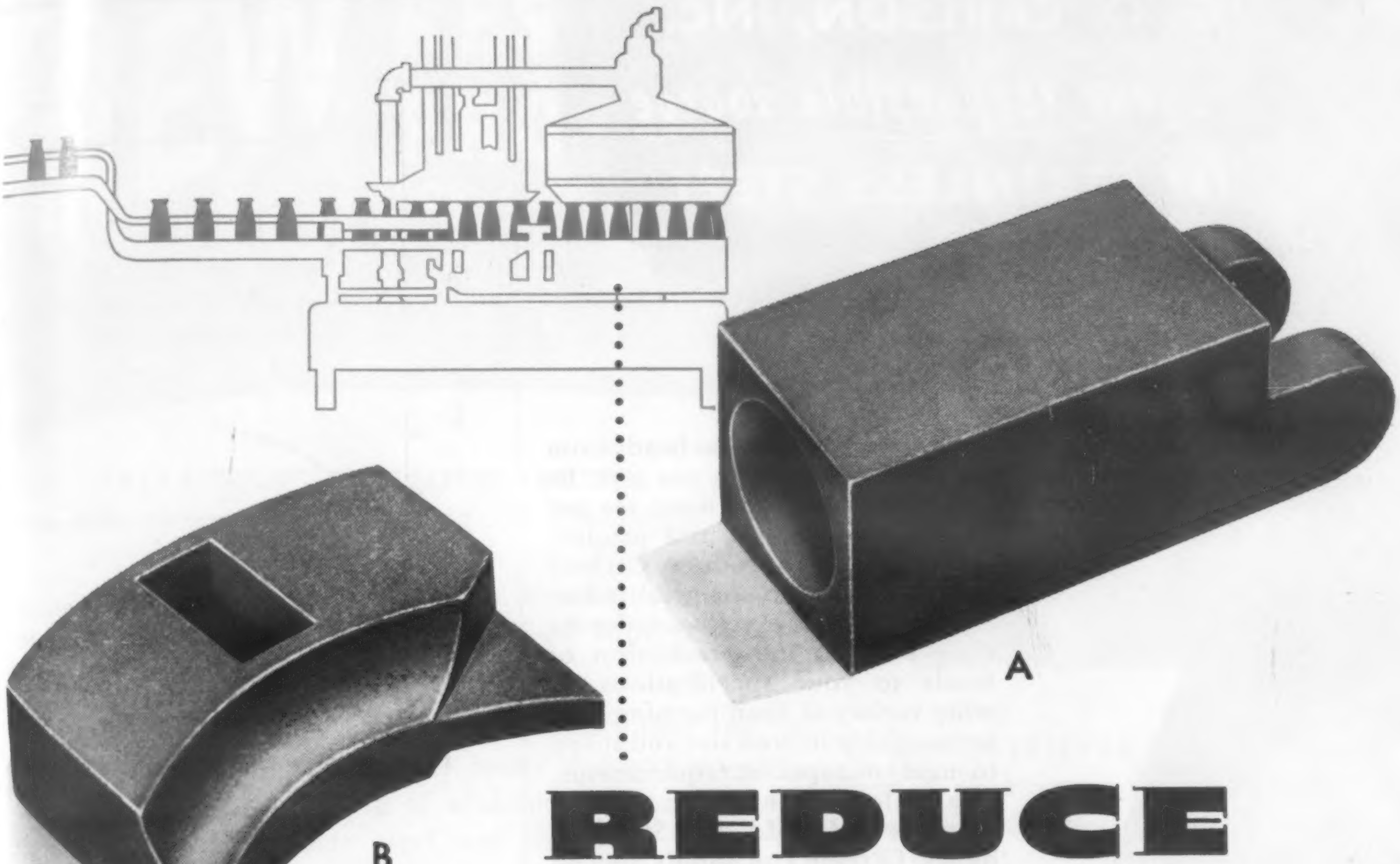
from seven- to 40-ply glass cloth, depending on calculated load for each area. The core varies in thickness from 1/2 to slightly less than 1/3 in. The upper and lower halves of the wings are molded and cured separately. Then they are bonded together, with prefabricated spars of the sandwich material providing internal support.

Cesna Planning Plastic Plane

The Cesna Aircraft Company is reportedly building an experimental personal-liason type light plane which will incorporate plastic parts in about three quarters of its air frame.

The experimental craft will have a far greater proportion of plastic in its structural parts than any other prospective production craft. The plane is for the low cost market.

(Continued on page 224)



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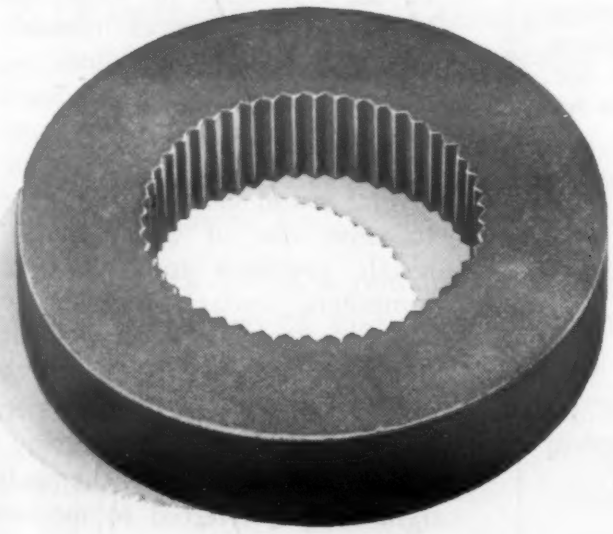

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In many cases life of component parts can be greatly extended by using castings of high-alloy grades impractical to machine. The ring illustrated (casting C), used in a fine wire feed mill, is an investment casting made of Crucible *Rexalloy*, a non-ferrous cobalt-chromium-tungsten alloy steel providing exceptional wear and abrasion resistance.

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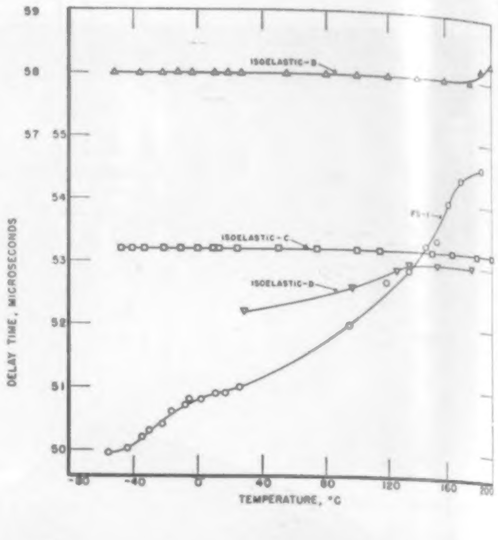

Ultrasonic delay time of two commercial isoelastic alloys is constant over a wide temperature range. Graph gives an indication of stability compared to a third isoelastic alloy and FS-1 magnesium alloy.

New Use for Isoelastic Alloys

Two commercial isoelastic alloys of the type used in watch springs, hold great promise as materials for use in ultrasonic delay lines, according to a recent Bureau of Standards investigation. The alloys, combinations of iron, nickel, chromium and several minor elements, are expected to solve one of the toughest materials problems in the design of computers, radar sets, and other ordnance and control equipment.

Delay lines are used to slow down or store signals in electric circuits. For very short delays involving signals of radio frequency, the electrical signals are converted to mechanical vibrations which are transmitted through a solid medium as high frequency sound waves then reconverted to electrical impulses. Since sound travels at a much slower rate than electrical conduction, a delay results which is a function of the length of the line and the speed of sound in the solid.

The use of isoelastic alloys for delay lines is apparently new, although such materials have been known and used in other applications, particularly watch springs, for over 50 years. Since one of the principal requirements of delay lines is thermal stability—the lines must

News Digest

have a constant delay time regardless of ambient temperature — isoelastic alloys appear to be a natural material for this application.

Up to the present time, only quartz and mercury have been used extensively as delay line materials, but neither is satisfactory for general application. Quartz is expensive, scarce, and extremely difficult to shape and machine. Mercury is even less satisfactory, as it is thermally unstable and is susceptible to mechanical shock, leakage, aging and contamination. Nevertheless, in the absence of a more suitable material, mercury was used in the long delay lines in the National Bureau of Standards Eastern Automatic Computer.

Ideally, a delay line should be a material capable of transmitting pulses up to the 10 megacycle frequency range without appreciable attenuation of distortion of the signal. It should be thermally stable, in that its delay time is not affected by temperature, and it should be easily machinable. Within limits, the isoelastic alloys test by the Bureau meet these requirements.

The Bureau of Standards investigation was chiefly concerned with finding a material for an ultrasonic delay line for a device requiring a 50 millisecond delay of a 10 megacycle signal. The most important quality sought was temperature stability through —50 to 200 F, which would qualify the material for use in military electronic applications.

The delay time of any ultrasonic delay line is determined by its length and the coefficient of rigidity, or shear modulus of the material through which the sound is transmitted, e.g., the more rigid the material, the faster it conducts sound. For most metals, as temperature increases the delay time also increases. For delay lines of certain alloys of iron and nickel, which have a very small positive expansion coefficient, the temperature coefficient of shear modulus must be very slightly negative in order to provide thermal stability in delay time.

The NBS investigated fourteen materials that appeared to hold promise for delay line use. The materials chosen for study included two magnesium alloys, a high purity and a commercial nickel, Invar, a 32% nickel-iron, 18:8 stainless, a 1% carbon tool steel, an aluminum single

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crystal and five isoelastic alloys. Characteristics of attenuation, distortion and temperature response were investigated for each material.

The investigators found that attenuation, or loss of signal strength is a combination of several factors. Besides losses in the line itself which are attributed to sound diffusion, scattering and elastic hysteresis, losses occur in the quartz crystal transducer and in the bond between the crystal and the delay line. Signal distortion was also found to have several sources. It can originate in the transducer, in the acoustical match of the transducer and delay line, and internally in the delay line due to scattered signals which are reflected back into the main beam. To investigate the internal factors, the Bureau made studies of the effect of chemical composition, cold deformation, annealing, specimen length, and sound path cross sections on the transmission of ultrasound.

Of all the materials studied, only two possessed satisfactory temperature stability over the range of —50 to 200 F. These two were commercial isoelastic alloys of iron. Both contained approximately 36% nickel, 7 to 8% chromium and other minor alloying constituents such as tungsten, manganese, silicon, copper and vanadium.

The most effective bond between the quartz crystal transducers and the delay lines was an epoxy type cement, slightly overcured.

Although the principal objective of the study was to obtain a line length which would produce a delay of 50 microseconds, specimens of various lengths were studied in order to determine the attenuation per unit length and the transducer or buffer loss associated with the various materials. Line length varied from ¼ in. to 6 in. The study revealed that there was little effect on the transmission of ultrasound attributable to specimen cross sectional area as long as it was not less than transducer cross section.

The use of isoelastic metal ultrasonic delay lines will simplify the construction and design problems in computer design, and will permit ordnance field equipment to incorporate circuits that were previously inoperable under any but laboratory conditions.

(Continued on page 230)

Why Allen Electric selected *shock-resistant*
G-E RUBBER-PHENOLICS
for this battery tester case

Four-part case for the Cell-Chek, a unique battery tester made by Allen Electric and Equipment Company, Kalamazoo, Michigan, is molded of shock-resistant G-E 12487 woodflour-filled rubber-phenolic.

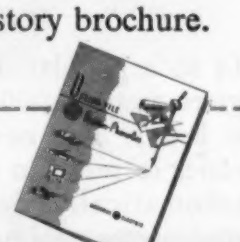
A battery tester leads a rugged life. Subject to constant handling in auto repair shops and garages, in constant contact with engine parts, its case must be *extra strong.*

That's why Allen Electric and Equipment Company selected a General Electric rubber-phenolic compound with which to mold the plastics case of its unique Cell-Chek battery tester. G-E rubber-phenolics provide the high impact strength required in this "rough service" application.

G-E rubber-phenolics also help Allen build other important sales features into its product: excellent dielectric properties, light weight for easy handling, black-satin finish for attractive appearance.

How can G-E rubber-phenolics help YOU?

Shock-resistant G-E rubber-phenolics offer you an excellent opportunity to use plastics for heavy-duty applications. They produce parts which resist breakage in assembly and service, accommodate large metal inserts without cracking, and permit lightweight designs without reinforcement. Where can *you* use them? Ask your molder about these amazing impact materials or send the coupon for a newly expanded case history brochure.



General Electric Company
Section 419-1B, Chemical Division
Pittsfield, Massachusetts

Please send me a free copy of "Design File—G-E Rubber-Phenolics." I want this information for:
( ) Reference purposes only ( ) An immediate application on ______

Name ______
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News Digest

Alloys for Delay Lines

Threaded joints in pipe and tube can be made as corrosion resistant as welds and flange joints with new Teflon based sealing compounds. The Teflon resin dopes operate as effectively as cement seals at temperatures up to 400 F, yet permit easy take-down and prevent thread galling in soft metal and plastics.

The thread sealer is a colloidal paste of Teflon in a water vehicle, and is chemically and biologically inert. It forms a film between threads which is effective enough to prevent galvanic corrosion in the joint between two dissimilar metals. Joints sealed with the compound do not require maximum torque and pull-up on fittings to secure and maintain a satisfactory seal.

The sealer is particularly useful in temporary or frequently disassembled installations, as joints may be tightened and backed off slightly without endangering the seal. Expensive fittings are preserved from galling and thread damage, as well as high stresses from overtight joints that might lead to localized stress corrosion. The slick film provided by the Teflon effectively lubricates the threads, and simplifies assembly and disassembly by hand since tools are needed only for final tightening.

Since the sealer is biologically and chemically inert, it is finding extensive use in the pharmaceutical and chemical processing industry, particularly as a sealer in stainless steel pipe installations.

Eric Anderson, of Eco Engineering, makers of a Teflon sealing compound called T-Film, said that his product is going into many military and atomic applications where corrosion has been a major problem. For example, the sealer's resistance to concentrated nitric acid and 96% peroxide has permitted the use of threaded joints in rocket motor fuel systems which previously required welded joints. The ease of disassembly has proved to be a particular boon in testing operations.

Commercial applications include submerged fittings in acid pickling tanks and alkali cleaning fluids.

H. C. McNeely, of Schnitzer Alloy, told M&M that the sealers were giving impressive performances with

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News Digest

his pipe and fittings customers in the pharmaceutical and chemical fields. He was particularly impressed by a shop test he tried, in which he tightened a one-inch stainless steel pipe into a fitting with a six-foot Stillson wrench. After three weeks at full tightness, there was no evidence of thread galling or failure.

In an aircraft hydraulic fluid line, the Teflon sealer was effective in a threaded joint in which lead and copper sealing alloys had failed. The dried sealer formed an effective compression seal in the joint.

The sealers are expensive—T-Film sells for $1 an ounce, which is about enough to dope 15 joints, but in critical applications it can lead to considerable economies.

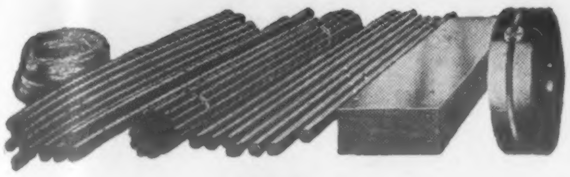
The temperature and pressure range of the sealer is from sub-zero to 400 F and from 16 or more inches of vacuum to about 250 lb per sq in. largely dependent on the number and size of thread. Because it is chemically inert, and will not contaminate pipe contents, a wide field of application is open in the food, chemical, and pharmaceutical processing industry.

Navy Converts to Rectifiers

Selenium and germanium rectifiers have made the grade in the U. S. Navy for shipboard applications.

Rectifiers are gradually displacing motor generators for Navy ships because of their efficiency, ease of repair, silent operation, and other valuable characteristics. Until recently, motor generator sets have been the best a.c. to d.c. conversion units from an overall viewpoint, but the introduction of new higher powered rectifiers changed the picture considerably. The long, maintenance-free life of selenium and germanium rectifiers and simplicity of assembly and mounting are cited as factors in their favor. One of the biggest advantages is that any required number of plates or disks can be easily assembled to make up rectifier units suitable for any required amount of d.c. power.

(Continued on page 234)

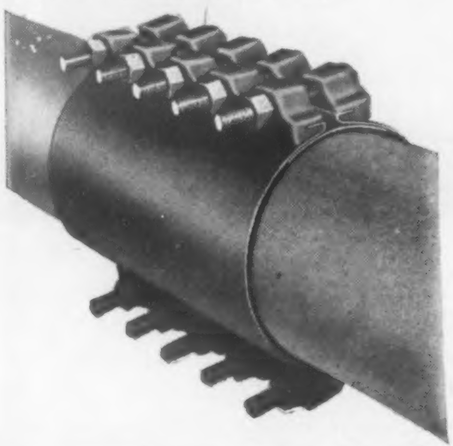


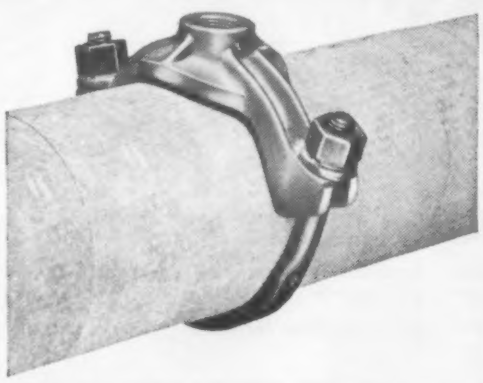
BRIDGEPORT BRASS COMPANY

COPPER ALLOY BULLETIN

Bridgeport Brass Co. MILLS IN BRIDGEPORT, CONN. AND INDIANAPOLIS, IND.—IN CANADA: NORANDA COPPER AND BRASS LIMITED, MONTREAL

Full Circle Clamp Coupling—copper strip for the band and Silicon Bronze screws and nut fasteners give strength and corrosion resistance. Courtesy Smith-Blair, Inc., South San Francisco, Calif.





Bronze Service Clamp for connecting risers. The cast bronze saddle and Neoprene gasket are assembled with a Silicon Bronze U-bolt and nuts for strength and long service life. Courtesy Smith-Blair, Inc.

Copper and Silicon Bronze Improve Repair and Service Clamps

Dependability, ease of installation, and excellent resistance to water and soil corrosion are characteristics of the metals used in the construction of clamps for sealing leaks, coupling pipes, and for service connections.

Illustrated is a Smith-Blair full-circle clamp coupling made from two half-circle bands of cold rolled, tough pitch copper, lined with molded rubber gaskets bonded to the copper. When firmly clamped together by means of high-strength silicon bronze bolts and nuts, this clamp enables one man to permanently repair a broken or cracked pipe in a few minutes with a minimum amount of excavating.

The fact that copper is flexible, as well as enduring, was an important factor in its selection. The heavy copper sleeve gives uniform distribution of the clamping pressure without crushing. This is very desirable for coupling cast iron, and especially for cement-asbestos pipe.

Silicon Bronze for High-Strength Service Clamps

The bronze service clamps are constructed with U-bolts made of silicon bronze wire or rod. Bolts made from Bridgeport's Silicon Bronze (609) (approx. 98% copper, 2% silicon) have a tensile strength of approximately 90,000 psi. Silicon bronze is so close to copper in the electromotive series that there is no danger of galvanic corrosion between the copper sleeve and the silicon bronze bolts. It also has the corrosion resistance of copper as well as the toughness of mild steel.

Silicon bronze is an engineering alloy that is fast replacing perishable metals for all types of fasteners. It is widely used in the electrical and marine fields for the construction of wire and cable connectors, pole-line hardware, marine hardware, sewage and waterworks, industrial equipment, valves, controls and all varieties of bolts, nuts, nails, and screw products used for outdoor construction.

Call on Bridgeport for Copper or Copper-Base Alloys

Bridgeport's Laboratory will be glad to cooperate with you in providing the right metal for your specific purpose. To obtain help on your metal problems or requirements, please contact your nearest Bridgeport office. Write for your copy of Bridgeport's "Technical Handbook" on company letterhead.

Duronze III Stops Accidents

The gate on the safety hook illustrated depends upon a lock pin made from Duronze III for controlling its opening and closing. The gate cannot be opened until the pin is pressed in.

Since the pin must function under all conditions, even when not lubricated, Duronze III (707) rod, an alloy of high strength and with excellent corrosion and wear resistance, was selected.

The sleeve for the pin is made from Ledrite 6 Brass rod because there is a low coefficient of friction between these two metals. The gate itself is cast Red Brass, and the washer on top of the hook is bearing bronze. The wide use of copper-base alloys reduces corrosion and prevents the freezing of moving parts when exposed to water and moisture even for long periods.

Duronze III (707), with 91% copper, 7% aluminum and 2% silicon, is supplied in rod form only, and has a tensile strength in the annealed state of between 85,000 and 90,000 psi. It answers the product designers' demand for high functional strength and, at the same time, eases the problems of the tool engineer and production department by its good machinability, which is 60% of free machining brass.

For additional information on Duronze III alloy, write for the Duronze Manual.

The safety pin made from Duronze III (Silicon Aluminum Bronze) controls the cast bronze gate which prevents the load from slipping off the hook. Courtesy E. D. Bullard Co., San Francisco.

(1307)

For more information, turn to Reader Service Card, Circle No. 396

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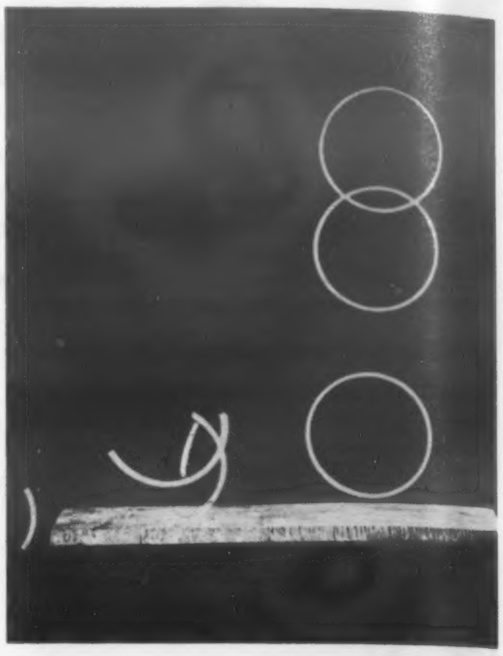


More bounce. Stroboscopic photo illustrates the relative impact strength of sections of pipe cast from Ductile Iron and gray iron. The photograph was taken shortly after impact of two sections dropped 20 feet to a steel plate. The common gray iron section on the left shatters, while the magnesium-containing Ductile Iron on the right bounces.

International Nickel Co. Inc.

Welding Society Show in May

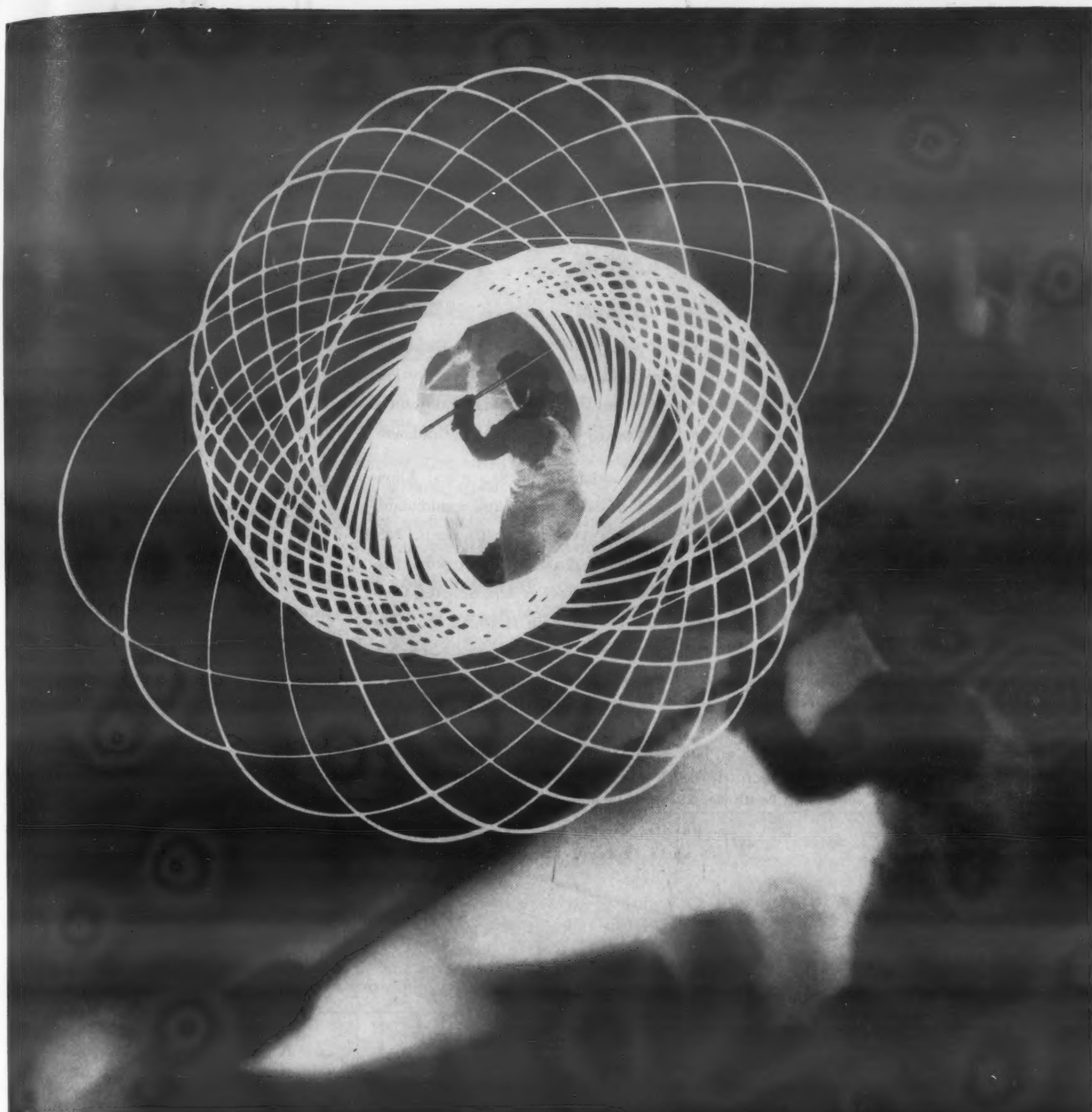
The latest developments in welding will be aired in Buffalo at the American Welding Society-sponsored Welding Show and National Spring Technical Meeting to be held May 4 through 7th.

The technical meetings, scheduled to take place in the Hotel Statler, will highlight papers on new welding methods, and methods for welding the new metals and alloys now available to industry.

In addition to presenting machinery displays at the exposition, the Welding Society has arranged for tours of the major industrial plants in the area.

Advance registration cards and hotel information may be obtained from the American Welding Society, 33 W. 39 St., New York 18, N. Y.

(Continued on page 236)



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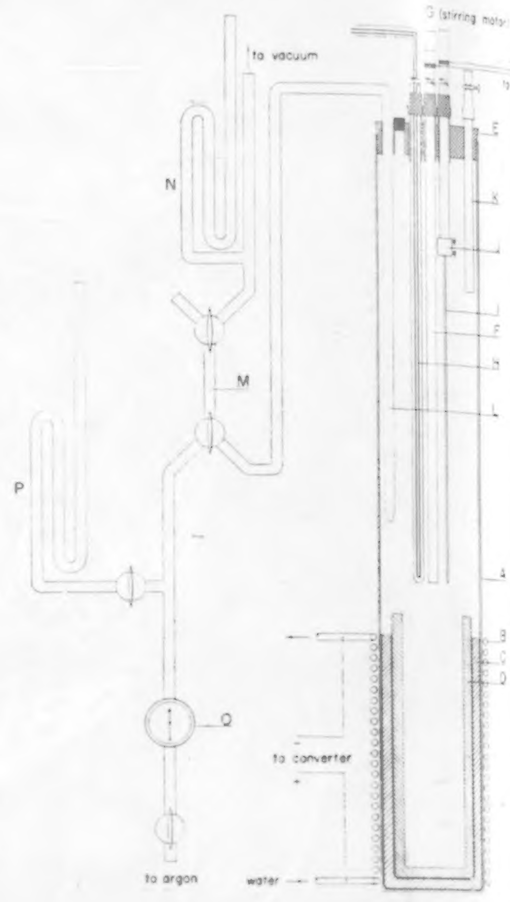


Molybdenum electrodeposition apparatus for fused salt electrolytic process. A. Gas tight cylinder. B. Induction furnace coil. C. Ceramic cylinder for insulation. D. Graphite crucible. F. Cathode. H. Thermocouple. L, J. Anode.

NBS Electrodeposits Pure Molybdenum

A promising new electrolytic method for the preparation of high purity metallic molybdenum is now in the final stages of development at the National Bureau of Standards. The fused salt bath electrolytic process is expected to provide a more economical and practical method for reducing molybdenum from ore. Research is progressing rapidly toward successful electroforming of solid molybdenum parts and electroplating high purity molybdenum coatings.

The electrolytic method is highly flexible and easily controlled, according to the NBS. By varying the electrolysis conditions, high purity molybdenum deposits have been formed which range from fine powders to thick, coherent layers.

High Melting Point

The need for more and better high temperature materials has focused in-

Announcing the

1954 redesign contest for Gray Iron castings

1st prize $500.00
2nd prize $250.00
3rd prize $100.00

Here's your opportunity to cash in *twice* on the products or parts you have redesigned for production in Gray Iron.

First: because the unique characteristics and castability of Gray Iron helped you replace a competitive material . . . more economically and more efficiently.

Second: by entering your redesign project in the Fifth Annual Gray Iron Founders' Society's *Redesign Contest* and win one of the substantial cash awards.

Here's all you have to do . . .

1. Select the best example of products or parts that you have redesigned for production in Gray Iron.

2. Give the facts for this switch to Gray Iron . . . how much you saved in labor and material costs . . . how much efficiency you gained and any other factors that led you to this decision.

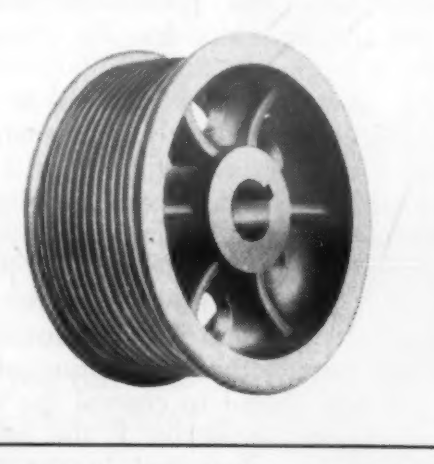
3. Submit an 8″ x 10″ glossy photo of the Gray Iron casting with your entry. And, if possible, submit a similar photo of the original product or component.

4. Get your entry in by JUNE 1, 1954 . . . closing date for contest. Address: *Redesign Contest,* Gray Iron Founders' Society, Inc., National City E. 6th Bldg., Cleveland 14, Ohio.

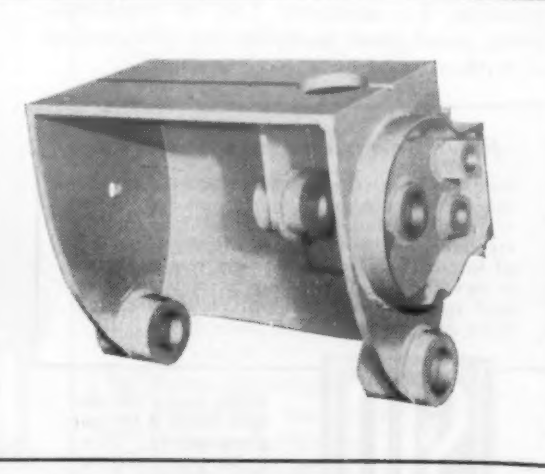
5. Contest is open to all persons engaged in the metalworking trades . . . entries may be entered jointly by two or more individuals.

Examples of previous award winners . . . featured in the Society's recent National Trade Advertising

Production costs were cut 90% by redesigning this gear cover in Gray Iron to replace the original fabricated cover.



This cable drum was redesigned for production in Gray Iron with a cost saving of 41% per unit.



By redesigning this gearbox in Gray Iron, 45% was saved on original cost of fabricated gearbox . . . 41% on machine and labor costs.

GRAY IRON FOUNDERS' SOCIETY, INC.

NATIONAL CITY-E. 6th BLDG., CLEVELAND 14, OHIO

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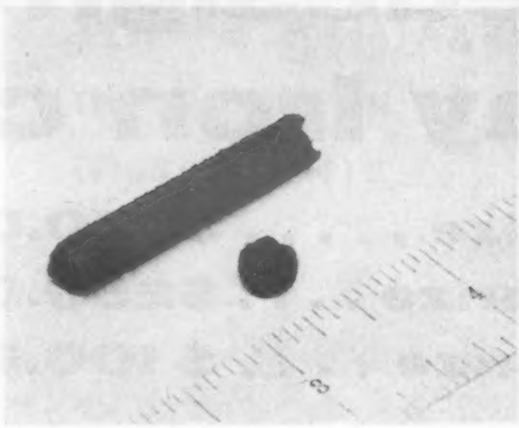


Electroformed tube and cup of molybdenum. Tube was hard and brittle but mechanically sound. Density of material was 9.4, or about 94% of theoretical density of molybdenum. The tube was deposited on a steel cathode coated with .001 in. silver.

creasing attention on pure molybdenum in the last few years. Molybdenum's melting point of 4750 F is exceeded only by tungsten, tantalum, rhenium and osmium among metallic elements. Molybdenum has good toughness at relatively high temperatures and in general, the strength and creep resistance of molybdenum and molybdenum-base alloys are better than iron, nickel and cobalt base alloys at temperatures above 1600 F.

Electrolyte

The NBS electrolytic process uses an electrolyte of fused hexachloromolybdate and potassium, sodium and lithium chlorides. By changing the temperature and composition of the electrolyte, the deposit is controllable within fairly wide margins. At a temperature of 1650 F a 1:1 mixture of hexachloromolybdate and sodium and potassium chlorides deposits a coarse powder of high purity molybdenum. With an eutectic mixture of potassium and lithium chlorides, varying the temperature of the bath was found to control the form of deposit. At 1100 F the molybdenum was deposited in the form of thick, coherent layers, while at higher temperatures a powdered deposit formed that grew finer as temperature increased.

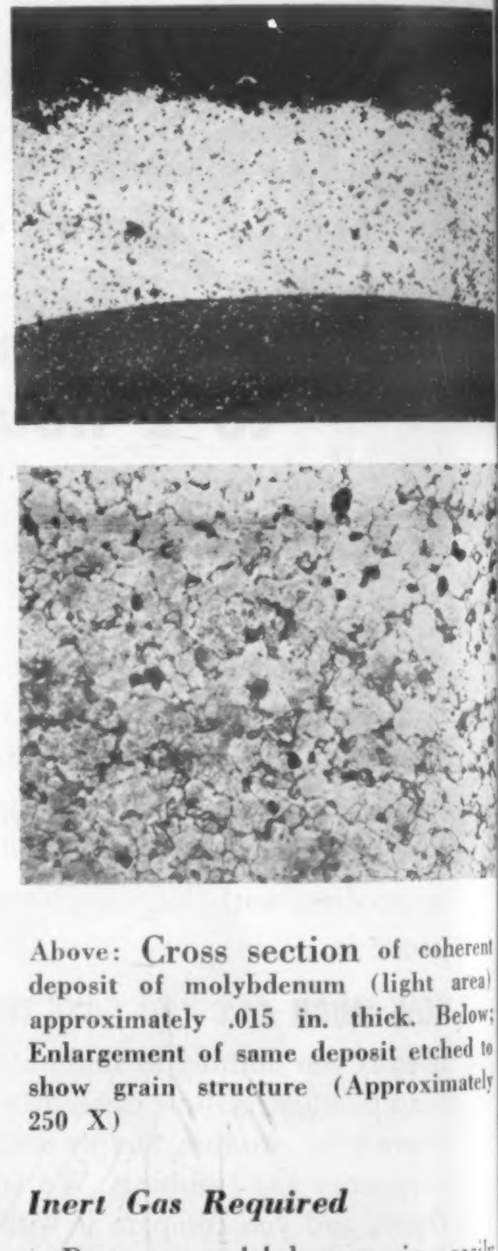
Investigations are underway to adapt the process to electroforming, electrowinning and electroplating.

Better Method

The electrolytic method of producing pure molybdenum promises sev-

News Digest

eral advantages over present methods. Molybdenum is currently produced as a powder from the reduction process of hydrogen with molybdic oxide. The process offers little control over the powder grain size and due to the large surface area of the fine powder so produced, extreme care must be exercised to avoid undesirable oxidation. Extensive purification is necessary before the powder can be used to form parts by powder metallurgy techniques or ingots through arc melting.

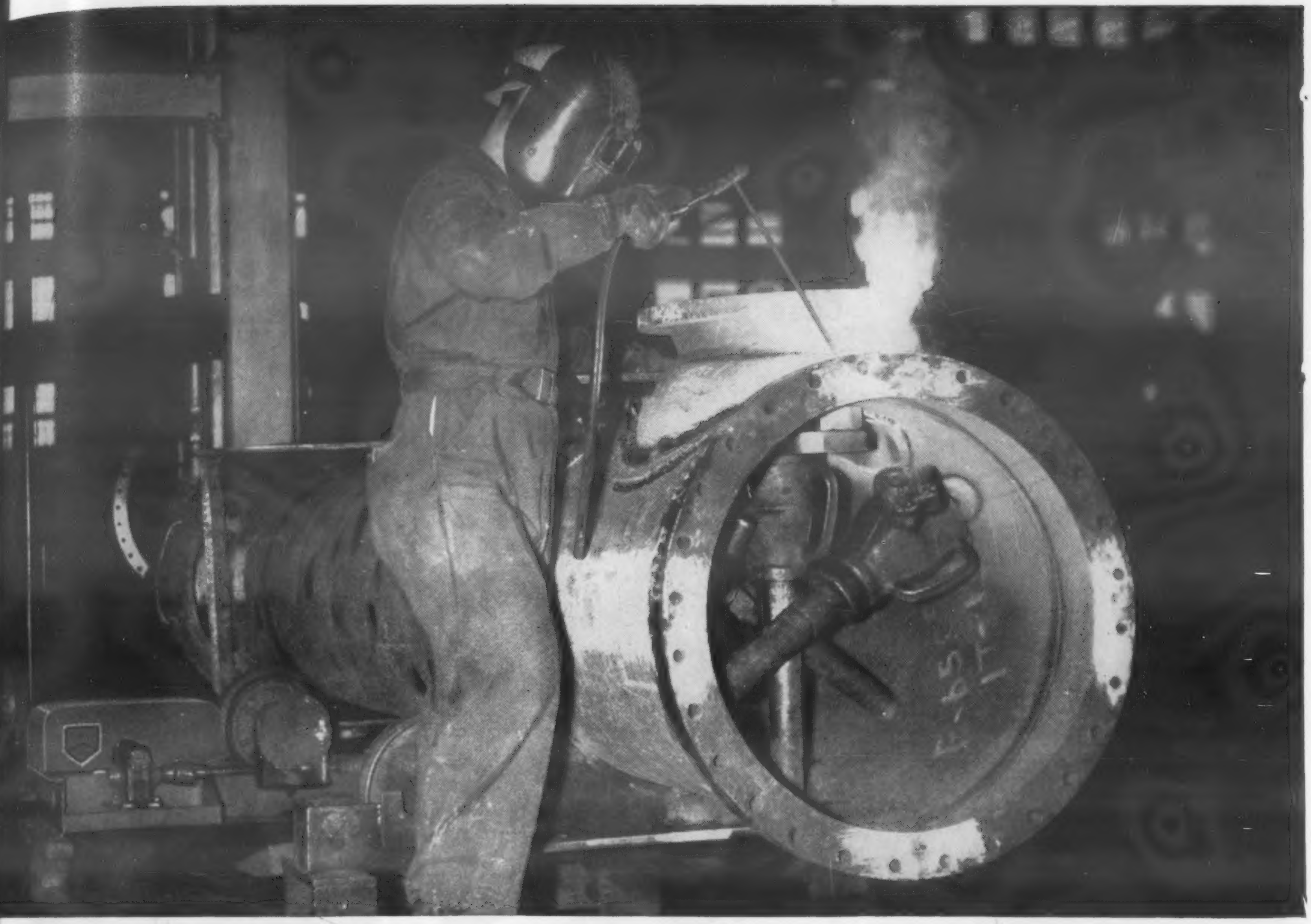


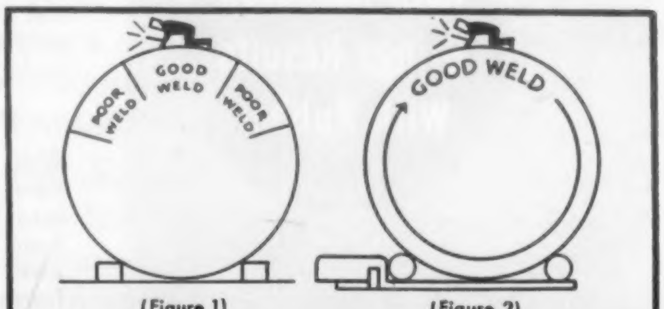
Above: Cross section of coherent deposit of molybdenum (light area) approximately .015 in. thick. Below: Enlargement of same deposit etched to show grain structure (Approximately 250 X)

Inert Gas Required

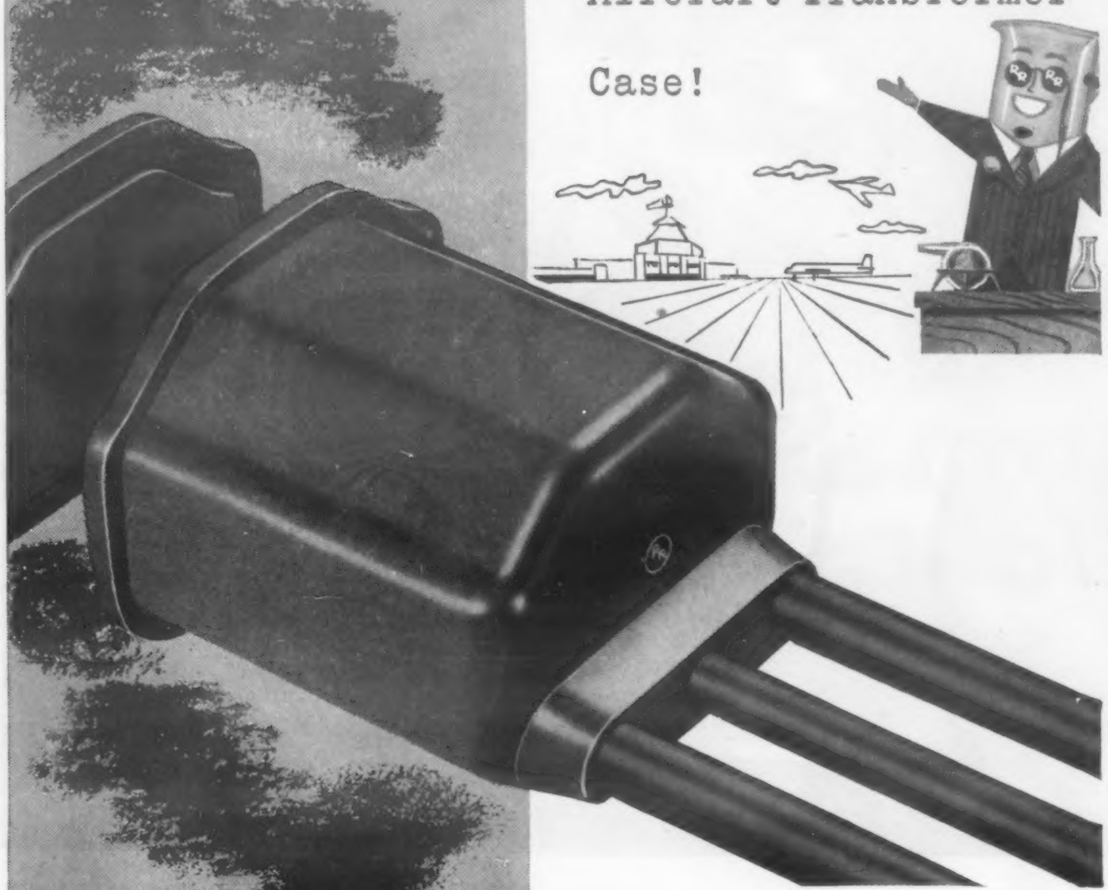
Because molybdenum is easily oxidized at high temperatures, the electrolytic process must be carried out in an inert atmosphere. Contamination by atmospheric oxygen or oxy compounds was found to reduce current efficiency and cause impure deposits. As a result all materials used in the electrolyte must be carefully dehydrated and purified.

Electrolytic deposits of molybdenum adhere well to the cathode, and are easily separated from solidi-





(Figure 1) (Figure 2)



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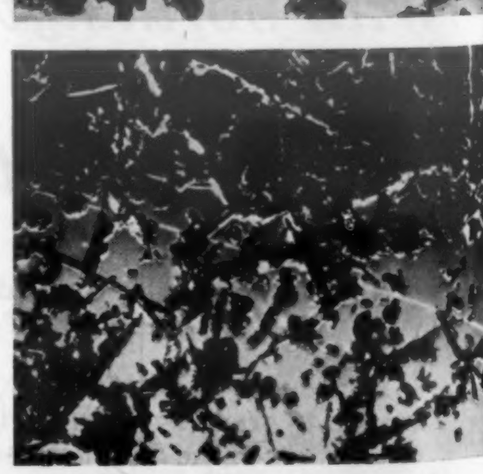
fied electrolyte by leaching with dilute hydrochloric acid. Deposited molybdenum is more than 99.9% pure and contains as low as 0.026% oxygen. Density of coherent deposits is 9.6, or 94% of the theoretical density of molybdenum.

Adequate Supply

The fact that molybdenum is the only refractory metal in adequate supply in the U. S. lends even greater importance to the new purification and forming technique. Molybdenum is one of the very few metals that is not in part imported by this country. The largest primary source of molybdenum in the world is the ore body at Climax Colorado, which accounts for about 2/3 of the entire world's supply. The mine, the second largest underground operation in the world, is expected to produce over 42 million pounds of molybdenum this year.

(Continued on page 244)



Different powder grain configurations produced by changes in electrolyte conditions. Above is a typical coarse powder with average grain size running about .01 in. Below is a dendritic deposit obtained from the same electrolyte with the concentration of molybdenum reduced. Needles are up to 1/20 in. long and are nearly monocrystalline in form.

For more information, turn to Reader Service Card, Circle No. 496

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ASA Approved 266 Standards in '53

American Standards now in use total over 1400 according to 1953 annual ASA report. Last year, 81 new standards were approved, 185 revised. Most new standards are in the field of civil engineering and construction, although as usual, ASA work extends throughout science and industry. New standards for materials including the following:

A21.3-1953	Specifications for cast iron pit cast pipe for gas.
A21.6-1953	Specifications for cast iron pipe centrifugally cast in metal molds for water or other liquids.
A21.7-1953	Specifications for cast iron pipe centrifugally cast in metal molds for gas.
A21.8-1953	Specifications for cast iron pipe centrifugally cast in sand-lined molds, for water or liquids.
A21.9-1953	Specifications for cast iron pipe centrifugally cast in sand-lined molds for gas.
A21.11-1953	Specifications for a mechanical joint for cast iron pressure pipe and fittings.
C7.25-1953 ASTM B 187-52	Specifications for copper bus bar, rod, and shapes.
C7.26-1953 ASTM B 188-52	Specifications for seamless copper bus pipe and tube.
C7.27-1953 ASTM B 236-52T	Specifications for aluminum bars for electrical purposes (bus bars).
C7.28-1953 ASTM B 245-52T	Specifications for standard weight zinc-coated (galvanized) steel core wire for aluminum conductors, steel reinforced.
C7.29-1953 ASTM B 263-53T	Method determining cross-sectional area of stranded conductors.

(Continued on page 246)

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C9.4-1953	Nylon fibre covered round copper magnet wire.
C33.1-1953	Flexible cord and fixture wire (July 1952 (fourth) edition of UL standard for flexible cord and fixture wire, excluding paragraphs 5 and 6, and 386 to 480 thereof).
B1.9-1953	Buttress screw threads.
B5.30-1953	Knurling.
B5.31-1953	Involute spline and serration gages and gaging.
B5.32-1953	Designation and working ranges of surface grinding machines of the reciprocating table type.
B5.33-1953	Designation and working ranges of plain cylindrical grinding machines.

Other Available Literature

Irons and Steels • Parts • Forms

Carbonyl Iron Powder. Antara Chemicals, Div. of General Dyestuff Corp., 31 pp, ill. Description, use and formulation of high purity carbonyl iron powders for electronic and powder metallurgy use. (60)

Magnetic Materials. Arnold Engineering Co., 8 pp, ill. Tables, No. GC-106. Properties and applications of magnetic materials. Hysteresis loops, magnetization curves. (61)

Steel Casting Design. Atlantic Steel Castings Co., ill. Offers detailed information on how to economically design steel castings. (62)

Small Swaged Parts. The Bead Chain Mfg. Co. Describes Multi-Swage process for swaging small metal parts from flat stock. Shows advantages and applications of method. (64)

Steel Plate Fabrication. Biggs Boiler Works Co., 6 pp, ill, No. 531. Profusely illustrates the facilities of this company for designing, engineering and fabricating products of steel plate. (65)

Stainless and Nickel Tubing. J. Bishop & Co. Platinum Works, 8 pp, ill. Stainless steel and nickel alloy tubing and small tubular specialties. (66)

Steel Tubing. Bundy Tubing Corp., 11 pp, ill. Steel tubing for various industrial applications. (67)

Precision Investment Castings. Cannon Muskegon Div., Nugent Sand Co., Inc., 4 pp, ill. Gives the many advantages of using Master Met certified alloys in precision investment casting operations. (68)

Metal Stampings. Carroll Pressed Metal Co., Inc., 6 pp, ill. Features the facilities of this company for producing a complete line of metal stampings. (69)

Rolled and Welded Parts. The Cleveland Welding Co., 8 pp, ill. Describes welded circular and rolled steel parts, their advantages in economic and physical aspects and their applications. (70)

Steel Design. Climax Molybdenum Co., 72 pp. Entitled "3 Keys to Satisfaction", booklet provides many design hints to assist designers of steel components. (71)

Gray Iron Castings. Dostal Foundry Machine Co. Permanent mold gray iron casting facilities. (72)

Aluminum and Stainless Steel Parts. Falstrom Co., 4 pp, ill, Nos. 140 and 141. Fabrication of parts, components and equipment from aluminum and stainless steel sheet. (73)

Gray Cast Iron. Gray Iron Founders' Society Inc. Booklet gives mechanical and engineering characteristics of gray cast iron. Includes details for designing cast components. (74)

Perforated Materials. The Harrington & King Perforating Co., No. 62. Catalog gives data on fabrication methods, how to order, types of perforation and uses of perforated materials. (75)

Coil Inserts. Heli-Coil Corp., 2 pp, ill, No. 652. Heli Coil inserts for screw threads, taps and gages. Engineering information in tables, for design data, power tools, fit and depth. (76)

Precision Casting. Howard Foundry Co., 6 pp. Characteristics and physical properties of ductile iron in comparison with other metals and a reprint of an article entitled "Design of Precision Cast Parts". (77)

Stainless-Clad Steels. Ingersoll Div of Borg-Warner Corp. Folder describes IngAclad, 20% cladding of stainless steel bonded to backing of carbon steel. (78)

Sheet Metal Fabrication. Kirk & Blum Mfg. Co., 38 pp, ill, No. F 3-652-NL. Profusely illustrates the facilities of this company for fabricating sheet metal in a variety of parts and assemblies. (79)

Lead-Bearing Steel Bars. La Salle Steel Co., 8 pp, ill, No. 8. Properties and applications of a complete line of La-Led free-machining, lead-bearing steel bars. (80)

Malleable Castings. The Malleable Founders' Society, 8 pp, ill, No. 47. Analysis of good practice in tolerances and specifications of malleable castings. (81)

Meehanite Castings. Meehanite Metal Corp., 20 pp, ill, No. 37. A series of case histories showing how in recent months critical material shortages have been solved by the use of Meehanite castings. (82)

Alloy Casting. Michiana Products Inc., 16 pp, ill. Description of facilities for producing alloy castings. (83)

Powdered Metal Parts. Michigan Powdered Metal Products Co. Describes facilities and scope of Michigan's powdered metal parts production. (84)

Threaded Stampings. Mohawk Mfg. Co., 2 pp, No. 851. Illustrates variety of products produced by Mohawk's stamping processes, guaranteeing uniform threaded parts with uniformly threaded holes. (85)

Tubing. Ohio Seamless Tube Div., Copperweld Steel Co., 8 pp, ill. Specifications and applications of a variety of Ostuco seamless and welded tubing. (86)

Expanded Metal Meshes. Penn Metal Co., Inc., 24 pp, ill, No. 493EM. Detailed information on Penmetal Expanded Metal, sheet metal that has been slit and expanded up to 10 times its original width. (87)

Steel Tubing. Rochester Products Div., General Motors, 12 pp, ill, No. 271. Features typical applications of GM tubing made in both single and double walls of steel. (88)

Roll Formed Shapes. Roll Formed Products, 24 pp, ill, No. 1053. Shows production procedures and advancements in roll forming shapes from ferrous and nonferrous metals. (89)

Stainless Steel. Sharon Steel Corp., 12 pp, ill. Mechanical properties, fabrication and applications of Sharon 430 stainless steel. (90)

Sheet Metal Fabrication. Stolper Steel Products Corp., 4 pp, ill, No. 2. Features case histories of sheet metal design and fabrication offered by this company. (91)

Steel Weldments. Struthers Wells Corp., Process Equipment Div., 16 pp, ill, No. W52553. Profusely illustrates a complete line of steel weldments engineered and fabricated by this company. (92)

Steel Hydraulic Tubing. Summerill Tubing Co., Div. Columbia Steel and Shafting Co., 8 pp, ill. Discusses tubing requirements, specifications for hydraulic applications, and advantages of steel seamless tubing. (93)

Alloyed Gray Iron Castings. Superior Foundry Inc., 8 pp, ill. Gives advantages, specifications, and illustrates production methods of Superior's electric furnace process for producing alloyed gray iron castings. (94)

Permanent Magnets. Thomas & Skinner Steel Products Co., Inc., 12 pp, ill. Alnico 2, 3 and 5 standard magnets in stock. Bars, rings, channel bars, horseshoe shapes. Tables of magnetization curves, energy curves and physical properties. (95)

Cold Rolled Strip Steel. Thomas Strip Div., Pittsburgh Steel Co., 50 pp. A handbook for users. Contains tables on finishes, size ranges, tempers and weights. (96)

Steels. Timken Roller Bearing Co., Steel & Tube Div., Canton, Ohio. Complete catalog of steels produced by this company. Request on company letterhead direct from Timken.

Small Precision Metal Parts. Torrington Co., 4 pp, ill. Illustrates the various small precision metal parts custom-made by the Specialties Div. of Torrington. (97)

Alloy Steel Castings. Unitcast Corp., 2 pp. Specifications, characteristics and uses of T-loy 42, alloy steel castings. (98)

Stainless Steel Castings. Waukesha Foundry Co., 4 pp, ill, No. WF-6. Discusses the facilities of this company for producing corrosion resistant high alloy, heat resistant stainless steel castings. (99)

Powder Metal Parts. Wel-Met Co., 12 pp, ill. Design factors, possibilities, and applications of powder metallurgy. Includes typical designs and powdered metal properties. (100)

Nonferrous Metals • Parts • Forms

Wire Rod and Strip. Alloy Metal Wire Co., Inc., 4 pp, ill. Profusely illustrates the facilities of this company for producing wire rod and strip for a variety of industries. (102)

Aluminum Parts and Forms. Aluminum Goods Mfg. Co., ill, No. A-77. Booklet entitled "Well Prepared to Serve" gives company's facilities for producing aluminum stampings and fabrications. Lists many items being made for current defense effort. (103)

Aluminum Castings. Aluminum Industries Inc., 4 pp, ill, No. 20A. Describes this company's facilities offered to industrial plants that need aluminum castings for defense jobs. (104)

MANUFACTURERS' LITERATURE

Rhodium. Baker & Co. Inc., 23 pp, ill. Data and directions for electroplating with rhodium. (105)

Copper and Copper Alloy Specifications. American Brass Co., 28 pp, No. B-34. Revised index gives up-to-date specifications of various national engineering societies and government agencies, including military (Munitions Board, Dept. of Defense). (106)

Engineering Bronzes. American Crucible Products Co., 12 pp, ill. Includes complete data on facilities, technical information, case histories and applications of Promet bronzes. (107)

Precision Investment Castings. American Precision Casting Corp., 8 pp, ill. Shows the steps involved to obtain precision investment castings using the "lost wax" process. (108)

Specialty Metals. American Silver Co., Inc., 4 pp, No. 9B. A brief listing and description of products which include ultra-thin gage metals, clad metals, contact materials and brazing alloys. (109)

Aluminum Alloys. Apex Smelting Co., 24 pp, ill. Discusses composition, typical mechanical properties, heat treatments and basic foundry applications of the standard aluminum alloys produced by Apex. (110)

Magnesium. Brooks & Perkins Inc., 8 pp, ill. Describes the facilities and services of this company for fabricating magnesium. (111)

Investment Castings. Casting Engineers, Inc., 4 pp, ill, No. 17. Discusses advantages of investment castings and characteristics of investment cast parts custom-made by this firm. (112)

Punch and Die Setting Alloy. Cerro de Pasco Corp., 20 pp, ill, No. A15. Properties and description of use of Cerromatrix for setting various types of dies and punches. Shows advantages over solid dies. (113)

Brass Wire Cloth. Chase Brass & Copper Co. Lists mesh, diameter of wire, percent open area, weight and other data on complete line of company's brass and copper wire cloth. (114)

Indium. Consolidated Mining and Smelting Co. of Canada, Ltd., 8 pp, ill. Uses, physical and chemical properties and history of Indium metal. (115)

Zinc Die Castings. Dollin Corp., 4 pp, ill. Describes high-speed automatic production of a variety of simple or intricate small zinc die castings. (116)

Castings. Eclipse-Pioneer Div. Foundries, Bendix Aviation Corp., 4 pp, ill. Discusses facilities of this company for producing a variety of sand, die and permanent mold castings of magnesium and aluminum. (117)

Tantalum Equipment. Fansteel Metallurgical Corp., 28 pp, ill, No. F-1030. Chemical and physical properties of tantalum and its uses in bayonet heaters, coils, heat exchangers and HC1 absorbers. (119)

Aluminum Alloy. Frontier Bronze Corp. Data on Frontier 40-E aluminum alloy combining high strength, good shock and corrosion resistance, and machinability. (120)

Magnesium Castings. General Magnesium Foundries, Inc., 4 pp, ill. Profusely illustrates the facilities of this company for producing magnesium castings. (121)

Investment Castings. Gray-Syracuse, Inc., 4 pp, ill. Various parts of precision cast brass, bronze, beryllium copper and steel. (122)

Copper and Brass Tubing. H & H Tube & Mfg. Co. Describes a complete line of seamless braze and lock seam copper and brass tubing. (123)

Precision Investment Castings. Hitchiner Mfg. Co., Inc., 6 pp, ill. Evaluates precision investment casting methods as to costs, production and properties of parts. (124)

Precision Die Castings. The Jelrus Co., Inc., 4 pp, ill. Illustrates cost savings in parts production through use of nonferrous precision die casting methods. (125)

Aluminum Alloy. William F. Jobbins Inc., 12 pp, ill. Includes advantages, composition, physical properties and applications of Almag 35, an aluminum casting alloy of the aluminum magnesium types. (126)

Abrasion Resistant Alloy. Jones & Laughlin Steel Corp., 36 pp, ill, No. AD155. Mining and earthmoving applications of Jalloy, abrasion and impact resistant steel. Gives technical data. (127)

Warehouse Service. Korhumel Steel & Aluminum Co., 6 pp, ill. Description of personalized warehouse service for steel, aluminum, phosphor bronze materials and other services. (128)

Silicon Bronze, R. Lavin & Sons Inc., 8 pp, ill, Vol. 9, No. 1. "The Lavingot" contains an interesting article on the subject of silicon bronze. (129)

Magnesium. Magline Inc., 8 pp, ill. Facilities for fabricating magnesium and producing sand castings. (130)

Magnesium Parts. Magnesium Products of Milwaukee, 4 pp, ill. Briefly describes facilities for designing and producing to order magnesium and aluminum parts. Shows several products. (131)

Composite Metals. Metals & Controls Corp., General Plate Div., 12 pp, ill, No. PR700. Attractively illustrates and describes the various composite metals, precious metals, electrical contacts and Truflex metals manufactured by General Plate. (132)

Ferrous and Nonferrous Metal Forms. Metal Goods Corp., 274 pp. Complete stock list and ordering information on metal parts and forms supplied by this company. (133)

Cored Forgings. National Cored Forgings Co., Inc., 8 pp, ill. Advantages and typical examples of cored forgings made of brass, bronze, copper and other nonferrous metals. (134)

Copper Tubing. Penn Brass & Copper Co., 6 pp, ill. Features of this company's seamless copper tubing. Includes tables of safe internal working pressures of various tubing sizes. (135)

Aluminum Castings. The Permold Co., ill. Shows how continuous, scientific control of Permold aluminum casting quality, to specifications, saves time and money. (136)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 255 or 256

Spun Shapes. Phoenix Products Co., Metal Spinning Div., 4 pp, ill. Describes Phoenix-spun methods for spinning spherical and extra deep-drawn contours. (137)

Extruded Aluminum. Precision Extrusions, 98 pp, ill. Lists over 4000 standard extruded aluminum shapes, rods, bars and tubing available without additional die service charge. (138)

Machining of Titanium. Rem-Cru Titanium Inc., 8 pp, ill, Vol. 1, No. 1. Discusses titanium machining practices and procedures recommended by customers having titanium application experience. (139)

Die Castings. Tri-State Die Castings Corp. New folder describes this company's facilities for production of aluminum and zinc die castings to order. (140)

Aluminum and Magnesium Castings. Rolle Mfg. Co., Inc., 16 pp, ill. Complete data on various magnesium and aluminum castings, plus views showing inspection procedures. (141)

Centrifugal Castings. Wisconsin Centrifugal Foundry Inc., 8 pp, ill. Foundry for centrifugal castings includes semi-machining and finish machining services. Chart of most widely used alloys: aluminum bronzes, manganese bronze, tin bronze and aluminum alloys. (142)

Nonmetallic Materials • Parts • Forms

New Basic Lubricants. The Alpha Corp., 8 pp, ill, No. 100. Presents standard industrial grades and compositions of a variety of Molykote Lubricants for use wherever bearing pressures and temperatures are beyond the capacity of conventional lubricants. (145)

Polyvinyl Chloride. American Agile Corp., Plastics Div., 18 pp, ill. Discusses physical and chemical properties of Agilene (polyethylene) and its many fabricated products. (146)

Felt Samples. American Felt Co., 8 pp. SAE felt standards and specifications, with samples exhibiting 16 different grades. (147)

Plastic Pipe. Anesite Co., 2 pp, ill. Specifications and applications of Black-Buty plastic pipe, designed to combat corrosion and avoid paraffin build-up in gathering lines and salt water disposal systems. (148)

Packaging Materials. The Angier Corp., 16 pp, ill. Describes facilities for solving industrial packaging problems and this firm's various types of wrapping materials. (149)

Gasket Materials. Armstrong Cork Co., 24 pp, ill. Complete data on various cork and rubber gasket materials made to meet government specifications. (150)

Aluminum Adhesive. Armstrong Products Co., 6 pp, ill. Features the properties of adhesive for bonding aluminum at contact pressure. (151)

Rubber Parts. Automotive Rubber Co., Inc. Series of bulletins show use of rubber for insulation or corrosion prevention in industrial equipment. (152)

Glass Fiber Sleeving. Bentley-Harris Mfg. Co., 4 pp. Describes new Fiberglas tubing and sleeving with high physical and dielectric properties. (153)

Plastic Pipe. Carlon Products Corp., 4 pp, ill. Contains factual informative answers to most frequently asked questions about carbon flexible plastic pipe and carbon rigid pipe. (154)

Ceramic Bodies. Centralab Div., Globe-Union Inc., 28 pp, ill, No. 720-10M. Comprehensive survey of this firm's ceramic production. Includes description of engineering properties of ceramics, design information, allowable tolerances, and indicates broad scope of ceramic products with data dimensions. (155)

Compounded Elastomers. Chicago Rawhide Mfg. Co., 32 pp, ill. Characteristics, properties and engineering applications of Sirvene compounded elastomers. (156)

Extruded Plastic. Conneaut Rubber and Plastics Co., 4 pp, ill, No. CR-53. Die making and production facilities of rubber and plastic extrusions. (162)

Commercial Glass. Corning Glass Works, No. B-83. "Properties of Selected Commercial Glasses" gives features of various types of glass and suggests industrial applications. (157)

Fabricating Plastics. Continental Diamond Fibre Co., 64 pp, ill, price 50¢. Reference book contains suggestions on general rules to follow, tooling recommendations and feeds and speeds. (158)

Molded Plastics. Dayton Rogers Mfg. Co., 4 pp, ill, No. 242. Describes this company's facilities for low cost production of molded plastics in small lots. Gives costs of sample products. (159)

Polystyrenes. Dow Chemical Co., 8 pp. Complete data on the various Styron formulations with regard to properties, methods of molding, and applications. (160)

Synthetic Elastic Compositions. E. I. du Pont de Nemours & Co. (Inc.), 8 pp, ill, No. A-1427. Presents typical applications and uses of Lucite, Polythene, Nylon, Butacite, Pyralin, Plastacele and Teflon. (161)

Glass Products. Dunbar Glass Corp., 4 pp, ill. Descriptions of this firm's various industrial glasses. Explains advantages of glass to the designer and gives physical properties. (163)

Glass-Reinforced Plastics. The Dynakon Corp., 7 pp. Gives mechanical, electrical, chemical and fabricating properties of Dynakon's glass-reinforced plastics materials. (164)

Nylon Molded Parts and Gears. John A. English & Co., Nylomatic Div., 1 p, No. 2. Price list of a complete line of nylon molded parts and gears—stock and special stock. (165)

Custom Molded Plastics. Erie Resistor Corp., Plastics Div., 4 pp, ill. Illustrated tour through Erie's new Plastics Div. headquarters showing equipment for manufactured custom molded plastics. (166)

Felt. Felters Co., 16 pp. "Felters Design Book" offers numerous ideas and technical data about felt. (167)

Polyvinyl Chloride Resin. Firestone Plastics Co., Chemical Sales Div., 3 pp, No. 3A. Data sheets discuss Firestone Exon 402A, a polyvinyl chloride resin specifically designed for unplasticized rigid applications. (168)

Plastic and Wood Composite. Gamble Bros., Inc., 4 pp, ill. Announces a new product, Gam-en-Wood, a combination of wood and the new synthetic Enrup. (169)

Plastics. General Industries Co., 16 pp, ill. Profusely illustrates the facilities of this company for producing a wide variety of low-cost custom-molded plastics. (170)

Fiber Glass for Vibration Resistance. Glass Fibers Inc., 8 pp, ill. Physical and chemical properties of Vibraglass, used in the new glass fiber shock and vibration absorbing machinery pads produced by Glass Fibers. (171)

Rubber Reinforcing Resin. Goodyear Tire & Rubber Co., Chemical Div., No. 601-B. Features and applications of Pliolite S-6B resin giving greater plasticity in rubber processing at low temperature. (172)

Self-Lubricating Bushings. Graphite Metallizing Corp., 8 pp, ill, No. 108. Describes Graphalloy grades for bushings and electrical uses. Bearing design data included. (173)

Plastic Molding. The Grigoleit Co. Folder describes this company's facilities for producing molded plastics. Includes designing, engineering, tooling, molding and finishing. (174)

Non-Plasticized Rigid Polyvinyl Chloride. H. N. Hartwell and Son, Inc., 3 pp. Physical, chemical and electrical properties of Boltaron 6200 Series rigid polyvinyl chloride material, available in the forms of sheet, rod, pipe tube and block. (175)

Plastics. Heresite & Chemical Co., 24 pp, ill. Oil-free thermosetting phenolic coatings, thermosetting and thermoplastic resins, molding compounds, synthetic rubber coating sheets and molded forms. (176)

Rigid Polyvinyl Chlorides. Kaykor Industries Inc., Div. of Kaye-Tex Mfg. Corp., 6 pp. Chemical and physical properties of Vyflex rigid polyvinyl chloride plates and sheets. (177)

Hardboards. Masonite Corp., 24 pp, ill. No. 1d/2. Properties and advantages of Preswood and other Masonite hardboards, and their relation to products design. (178)

Electrical Insulating Material. Mica Insulator Co., 4 pp, ill. Complete data on Isomica, a new and improved electrical insulation with higher dielectric strength, greater uniformity and better physical characteristics. (179)

Polyurethanes. Monsanto Chemical Co., 15 pp, No. 151. Description of a new type of product incorporating diisocyantes prepared from a polyfunctional hydroxyl compound for use as adhesive for bonding rigid materials. (181)

Polyester Resins. Naugatuck Chemical Div., U. S. Rubber Co., 18 pp, No. NC-51-7. Technical data on a complete line of Vibrin polyester resins for contact pressure laminating, low pressure molding and casting. (182)

Laminated Resinous Plastics. Panelyte Div., St. Regis Sales Corp., 19 pp, ill. Physical properties, industrial and chemical applications and fabrication of laminated thermosetting resinous plastic. (183)

Polyester Reinforcing Resins. Pittsburgh Plate Glass Co., 24 pp. Technical data on the Selectron 5000 series of polyester reinforcing resins. (184)

Precision Shapes. Precision Shapes Inc., 6 pp, ill. Fabrication process for continuous milling of shapes from solid rolled, drawn or extruded stock. (185)

Corrosion Resistant Gasketing. Products Research Co., 5 pp, ill. Features, advantages and specifications of Chromelock corrosion resistant gasketing material. (186)

Plastics. The Richardson Co., 2782 Lake St., Melrose Park, Ill., 24 pp, ill, No. 836. "Facts About Plastics" gives basic introduction to plastics, their production and uses in industrial and consumer products. Request direct from Richardson on company letterhead.

Closed Cellular Rubber. Rubatex Div., Great American Industries Inc., 8 pp, ill. Nonporous foamed rubber product for sealing, gasketing, cushioning, packaging, and other uses. (187)

Laminated Plastics. Synthane Corp., 4 pp, ill. Military government and other specifications of Synthane laminated plastics sheets, tubes and rods. (188)

Rubber Parts. Stalwart Rubber Co., 16 pp, ill, No. 51SR-1. Describes applications and fabrication of rubber compounds, designed to resist temperature, abrasion, chemicals and weathering. (189)

Molded Ceramics. Star Porcelain Co. Gives technical data on characteristics of molded ceramic products for electrical wiring, electrical heating and special purposes. (190)

Ceramic Laboratory Ware. The Thermal Syndicate Ltd. Technical descriptions, specifications and prices of Vitreosil ware, said to be superior to porcelain in some uses. (191)

Molded and Extruded Rubber Parts. Tyer Rubber Co., 8 pp, ill, No. 1P52. Detailed information on various types of molded and extruded parts of natural and synthetic rubber. (192)

Carbon-Graphite Parts. U. S. Graphite Co., 68 pp, ill, No. G-49. Properties, chemical resistance, limitations, assembly information, design aids and 60 applications of Graphitar. (193)

Rigidized Metal Bonded Plywood. U. S. Plywood Corp., 8 pp, ill. Gives special features, advantages and wide variety of uses for Armorply, sheet metal bonded plywood. (194)

Thermoplastic. Van Dorn Iron Works Co., 16 pp. Technical data on properties, available forms, fabrication and applications of Lucoflex, a rigid polyvinyl chloride. (195)

Thermoplastics. Westchester Plastics Inc., 4 pp. Advantages of using this company's services for all types of coloring in molding and extruding of plastics. (196)

Felt. Western Felt Works, 32 pp, ill. History of manufacture and uses of felt, including brief description of present-day methods and applications. (197)

Plastic Laminates. Winner Mfg. Co., Inc., 12 pp, ill. Features the varied facilities of this company and gives typical applications of its many plastic low-pressure laminate products. (198)

Finishes • Cleaning and Finishing

Coated Abrasives. Armour Sandpaper Works, 124 pp, ill. Catalog of complete line of coated abrasives. Includes tables. (199)

MANUFACTURERS' LITERATURE

Coated Abrasive Tools. Behr-Manning Div. of Norton Co., 6 pp, ill. Folder includes problems encountered and explains how they were solved with mechanical polishing coated abrasive tools. (200)

Rust-Inhibiting Paint Base. Bell-Ray Chemical Corp., 4 pp. Features advantages of using Chem-Bond, a rust-inhibiting paint base, on iron, steel, brass, copper, aluminum, etc. (201)

Barrel Finishing Compound. Blue Magic Chemical Specialties Co., 2 pp, ill, No. 1. Includes advantages and case histories of Blue Magic No. 1, a cutting and finishing compound for barrel finishing bronze, brass, copper, gold, silver, etc. (202)

Resin-Bonded Laminates for Finishing. The Chemical Corp., 20 pp, ill, No. PD-1R353. Data sheets discuss a variety of tanks, ducts, hoods, stacks and waste pipe for corrosion resistant use. (203)

Wear Resistant Coating. Electrolyzing Corp., 16 pp. Detailed data on the Electrolyzing Process for increasing the life and efficiency of metal parts subjected to wear, abrasion and corrosion. (204)

Precision Finishing Equipment. Hollywood Bronze Supply Equipment Div., 4 pp, ill. Specifications and prices of a complete line of immersion heaters, tanks, rectifiers, assemblies, etc. for finishing. (205)

Washing and Drying Machines. Industrial Machine Corp., 10 pp, ill. Profusely illustrates a complete line of industrial washing and drying machines for washing, rinsing, slushing and drying operations. (206)

High-Pressure Cleaners. J. P. Mfg. Co., 4 pp, ill. Typical applications of the new 2500 Series Whirlpool high pressure cleaners that degrease, wash, strip and clean in one operation. (207)

Abrasives. Metals Disintegrating Co., 4 pp, charts, No. 521. Chilled shot and diamond grit for metal finishing. (208)

Colored Silicone Finishes. Midland Industrial Finishes Co., ill. Reprint interestingly discusses the application of colored silicone finishes. (209)

Pickling Process. Neilson Chemical Co., No. 51-3. Complete data on Prep-pik-I phosphoric acid pickling process said to offer several advantages over sulfuric acid processes. (210)

Phosphate Coating for Drawing. Parker Rust Proof Co., 7 pp, ill. Theory of phosphate coatings as lubricants for drawing operations. Features successful applications and methods of applying coatings. (211)

Acid Additives for Finishing. Promat Div., Poor & Co., 12 pp. Technical data on the use of Promat acid additives in metal finishing operations. (212)

Mechanical Finishing. Roto-Finish Co. Folder describes uses and economies of Roto-Finish tumbling-type equipment for precision grinding, deburring and coloring metals. (213)

Electroplated Rhodium. Technic Inc., 1 p. Technical data sheet on electroplated rhodium also announces the availability of heavy rhodium plated deposits. (214)

Cleaning and Finishing Media. Almco Div., Queen Stove Works, Inc., 10 pp, ill. Features and applications of Supersheen Abrasive Chips and Compounds for barrel finishing and cleaning. Also data on finishing machines. (215)

Liquid Honing. Vapor Blast Mfg. Co., 4 pp, ill. Equipment for surface finishing by liquid honing, specifications and dimensions of equipment. (216)

Heat Treating • Heating

Induction Furnaces. Ajax Engineering Corp. Information on Ajax-Tama-Wyatt induction furnaces for melting metals with accurate temperature control and freedom from contamination. (217)

Box Muffle Furnaces. Burrell Corp., 4 pp, ill, No. 315. Includes specifications and prices of five "Unit Package" box muffle furnaces for low and high temperature testing operations. (218)

Furnace Heating Elements. Carborundum Co., Globar Div. Complete data on Globar silicon carbide heating elements, said to be efficient, safe and easy to repair. (219)

Electric Ovens and Furnaces. Cooley Electric Mfg. Corp., ill. Describes a complete line of electric ovens and furnaces produced by this company. Includes specifications. (220)

Roller Hearth Furnaces. Drever Co., 8 pp, ill, No. B-90. Profusely illustrates a variety of oil, gas or electrically heated, direct fired or radiant tube roller-hearth furnaces. Includes specifications. (221)

Salt Pot Furnaces. Eclipse Fuel Engineering Co., 8 pp, ill, No. D-50. Detailed specifications of a complete line of gas fired pot furnaces for hardening and drawing in lead, and heat treating salts. (222)

Electric Sintering Furnaces. The Electric Furnace Co., 4 pp, ill. Descriptions and uses of nine EF sintering furnaces. (223)

Heat Treating Equipment. Gas Appliance Service Inc., 7 pp, ill. Shows standard and special equipment for heat treating and gives typical applications for each type of furnace. (224)

Furnaces. C. I. Hayes Inc., 44 pp, ill, No. 112. Complete data on a variety of furnaces for hardening, tempering, carbonitriding, forge heating, sintering, annealing and tool heat treating, as well as on atmosphere generators and ammonia dissociators. (225)

Heat Treating Furnaces. Industrial Heating Dept., Westinghouse Electric Corp., 38 pp, ill, No. B-5459. Complete description of Westinghouse furnaces—large and small, gas and electric. (226)

Heat Treating Defense Equipment. E. F. Houghton & Co., 50 pp, ill. Technical data on heat treating and metal working operations involved in producing shells, rockets, guns, and other defense items. (227)

High Frequency Heating Units. Lepel High Frequency Laboratories, No. MM-7. Specifications, features and advantages of this company's low cost, high frequency heating units. (228)

Induction Heating. The Ohio Crankshaft Co. Describes plant survey and possible applications to which induction heating might be put for greater production economy. (229)

Cold Treatment Equipment. Revco Inc., 2 pp, ill. Describes cold treating cabinets for seasoning gages and precision tools, for testing, for shrink fits, and for aircraft rivet applications. (230)

Brass Cake Heating Furnace. W. S. Rockwell Co., 2 pp, ill, No. RF-6. Technical description of this firm's continuous cycle furnace or heating brass cakes. Includes specifications. (231)

Ammonia Dissociators. Sargeant & Wilbur Inc., 4 pp, ill, No. A.D. 10. Features, specifications and applications of a variety of this company's ammonia dissociators. (232)

Gas Burner. Selas Corp. of America, 8 pp, ill, No. SC-1009. Describes special design of tunnel type multiport gas burner that can be used in furnace or open-firing applications. (233)

Air Compressors. The Spencer Turbine Co., 12 pp, ill, No. 126-A. Performance curves, capacity tables and detailed descriptions of Turbo compressors for use in gas or oil fired heat treating equipment. (234)

Batch-Type Furnaces. Surface Combustion Corp., No. 50-E. Description and advantages of this company's Allcase batch-type furnaces. (235)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 255 or 256

Welding • Joining

Rubber-to-Metal Bonding. Acushnet Process Co., 8 pp, ill, No. 51-A. Supplement A to the Acushnet rubber data handbook gives more detailed information concerning the rubber-to-metal adhesion process. (238)

Tool Steel Electrodes. Alloy Rods, 7 pp, ill, No. AR52-1. General instructions on how to use tool-arc electrodes on the basic types of tool and die steels. (239)

Silver Brazing. American Platinum Works, 48 pp, ill. Reference manual on silver brazing discusses low temperature brazing, brazing alloys, design considerations and other topics. (240)

Stainless Fasteners Specifications. Anti-Corrosive Metal Products Co., Inc., slide indicator. Identifies the type of fastener specified by each A-N number pertaining to the stainless fasteners. Refers user to this company's catalog for more data. (241)

Weldment Assemblies. Continental Foundry and Machine Tool Co., 6 pp, ill. Advantages of large welded assemblies, typical applications, and production facilities available. (242)

Rosin Core Solder. Division Lead Co., 4 pp. Features Divco's X-25 rosin core solder, which provides flux activity at a temperature even before the solder is completely molten. (243)

Resistance Welding. General Electric Co., 16 pp, ill, No. GEA 5816. Analysis of resistance welding and a catalog of resistance welding equipment. (246)

Wing Nuts. Gries Reproducer Corp. Data on zinc alloy wing nuts, said to be strong, rust-proof, low cost, available in all commercial finishes and thread sizes. (247)

High Temperature Fastenings. Aero Div., H. M. Harper Co., 16 pp, ill. Complete list of screws, bolts, nuts and washers of high temperature corrosion resistant alloys

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and titanium. Includes tables of chemical and mechanical properties. (248)

Cotter Pins. Hobbs Mfg. Co., 4 pp, ill, No. 750. Features table of prices and sizes of a variety of Hoblock hammer-lock type and Loxit extended prong cotter pins. (249)

Welding Speed Steels. W. J. Holliday & Co., 4 pp, ill, No. 907. Detailed information on welding Speed Case (X1515), Speed Treat (X1545) and Speed Alloy Plate. (250)

Fastener. Huck Mfg. Co., 5 pp, ill. Description and specifications of Huck Lockbolts, new high shear strength fasteners incorporating principles of rivets and bolts. (251)

Brass and Bronze Fasteners. The Jacques Co., 26 pp, ill, No. 50. Price lists and specifications of this firm's fasteners, including various nuts, cap screws, bolts and washers. (252)

Stud Welding. KSM Products Inc., 27 pp, ill. Booklet explains correct use of stud welding equipment, and outlines steps and procedures to be followed. (253)

Solders. Kester Solder Co., 28 pp, ill. Complete analysis of properties and applications of a variety of Flux Core soft solder alloys and soldering fluxes. (254)

Arc Welders. Miller Electric Mfg. Co., 4 pp, ill. A complete line of transformer type welders for all applications of Heliarc processes. (255)

Welding Torches. National Welding Equipment Co., 16 pp, ill. Presents the many advantages resulting from using this company's welding torches. (256)

Resistance Welding. Sciaky Bros., Inc., 6 pp, ill, Vol. 3, No. 5. Discusses spot and seam welding used in producing aircraft parts more economically and to higher standards. (257)

Self-Locking Set Screws. Set Screw & Mfg. Co., 20 pp, ill. Illustrates and describes various types of standard and self-locking set screws with data on dimensions, prices, heads, points and materials. (258)

New Fastener. Shakeproof Inc., 16 pp, ill, No. AS-39. Describes Keps preassembled nuts and lockwashers claimed to eliminate lockwasher handling. (259)

Screws. Russell, Burdsall & Ward Bolt & Nut Co., 8 pp, ill. Presents principle of fastening, advantages and specifications of a complete line of Spin-Lock screws available in hex, pan, truss or flat heads. (260)

Forming • Casting • Molding • Machining

Die Casting Machine. A. B. C. Die Casting Machine Co., 4 pp, ill. Complete details and specifications of the 1-lb zinc ABC die casting machine. (263)

Cold Forming Lubricant. Detrex Corp., 8 pp, ill, No. 206-3. Complete data on the Detrex Extrudite Process for the cold forming of steel. (266)

Injection Molding. Guy P. Harvey & Son Corp., 1 p, ill. Includes specifications of the Vacurator, which offers rapid production of master patterns, formed hollow samples and zinc alloy sample molds. (267)

Plastics Molding Equipment. Improved Paper Machinery Corp., 4 pp, ill. Features and advantages of Impco injection-compression, plunger, transfer and injection molding machines for plastics. (268)

Drilling Machine. Wales-Strippit Corp., 8 pp, ill, No. DM. Describes features, setting up, operation and accessories of Wales drilling machine, designed for precision location of holes. (269)

Magnetic Perforating Dies. S. B. Whistler & Sons Inc., ill. Complete descriptions and applications of this company's magnetic perforating dies. (270)

Tube Mills. The Yoder Co., 65 pp, ill. Pros and cons of operating a tube mill, plus detailed information on the process. Also technical data on standard and other equipment. (271)

Inspection • Testing • Control

Radium Radiography. Atomic Energy of Canada, P. O. Box 379, Ottawa, Canada, 71 pp, ill, price $2.00. Detailed theory, equipment and applications of radium radiography. Available directly from Atomic Energy of Canada.

Testing Machines. Buehler Ltd., 8 pp, ill. Shows Amsler testing machines for tension, compression, torsion, shear fatigue, bending and ductility tests on various materials. (272)

Furnace Temperature Indicator. Claud S. Gordon Co., 2 pp, ill. Describes device which quickly indicates any deviation from desired furnace temperature. (273)

Metallurgical Laboratory Equipment. Harshaw Chemical Co., Harshaw Scientific Div., 12 pp, ill, No. D2637. Catalog describes and gives specifications of this company's available metallurgical laboratory equipment. (274)

Industrial X-ray Units. Keleket X-Ray Corp., 8 pp, ill, No. 212. Profusely illustrates various industrial x-ray units for nondestructive testing. (275)

Electric Control Thermometers. Minneapolis-Honeywell Regulator Co., Industrial Div., 10 pp, ill, No. 6482. Describes the Brown Circular Case Electric Control Thermometers, available either as indicators or recorders. (276)

Thermocouples. Revere Corp. of America, 4 pp, ill. Precision thermocouples of various types and accessory equipment. (277)

X-Ray Equipment. Westinghouse Electric Corp., X-Ray Div., 4 pp, ill, No. B-4787. Describes seven types of x-ray equipment for industrial application, and includes advantages. (278)

Process Control. Wheelco Instruments Div., Barber-Colman Co., 42 pp, ill, No. TC-10. Data book and catalog of thermocouples, radiation detectors, resistance bulbs and other accessories for indicating, controlling and recording instruments for use in process control. (279)

Hardness Testers. Wilson Mechanical Instruments Co., 12 pp, ill, No. DH-114. Descriptions and specifications of several Tukon hardness testers. Includes discussion of hardness testing and applications. (280)

General

Lettering Machine. Ralph C. Coxhead Corp., 4 pp, ill. Lists the many advantages of using the Vari-Typer lettering machine in the drafting room. (283)

Vacuum Pump. Kinney Mfg. Co., No. V51-A. Features, specifications and price information on the CVM3153 Midget Vacuum Pump. (284)

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For more information, turn to Reader Service Card, Circle No. 309

For more information, turn to Reader Service Card, Circle No. 455

The Last Word

Travelog

By the time this appears in print, its author will have been to and returned from the sunny state of California. Unless you have experienced it, it is hard to realize that one can leave a cold, miserable climate and within a few hours be warm and comfortable. Perhaps I insulted the several Chambers of Commerce in California by marching down their principal streets wearing a top coat. I learned, though, in a few days and almost went native; although I couldn't quite bring myself to wear one of those gaudy shirts.

Observation

Los Angeles and surrounding areas seem to be as bustling as ever despite drops in defense work, although overtime work is rapidly diminishing. Now the companies which once served local aircraft industries almost exclusively are casting their eyes eastward for business. This is added reason to expect the competitive pot to boil more energetically. Western industry has long since passed the stage of being a forgotten step-child of the American business family. Many of the developments now spreading rapidly can credit this area with their inception or widespread adoption. Among a few which come to mind are reinforced plastics auto bodies, adhesive bonding, inexpensive shell molding methods, unusual extrusions in steel and aluminum and square spinnings of which we have spoken previously.

Thoughts While Touring

When we hear of certain metals being expensive we are inclined to tsk, tsk the whole idea as being nonsense and unnecessary. Opinions can be changed, though, and mine were somewhat during recent travels. For example, you can be crossing a desert with scarcely a sign of habitation when all of a sudden some smokestacks appear. Then right out of nowhere you see an ore recovery plant, handling manganese, titanium or some other metal. A little further, in the mountains you will see the treacherous trails over which ores must be hauled before they can even be started on their way into products for you and me. At that point the question arises: "How can they be mined, processed and converted into finished form so cheaply."

The Materials Show

The program has now been completed and speakers secured for the Second Basic Materials Conference to be held in conjunction with the Materials Show in Chicago, May 17, 18, 19 and 20. From this vantage point it looks as if both the Show and Conference will be bigger, better, and busier than last year's. Topics selected for the 1954 Conference include: Materials for Rockets and Guided Missiles; Corrosion and Erosion; New Metal Forming Processes; Where to Use Nonmetallic Materials; Adhesive Bonding, and How to Operate a Materials Department. Speakers enlisted are not only capable of presenting good papers, but also are so well versed in their subjects as to promise spirited and informative question and answer sessions after the formal talks. This might be a time to inject the commercial and suggest—even urge—that you plan to attend. More than 300 attendees at the 1953 Conference can tell you of the value of these affairs.

Contribution

From time to time other members of the staff make suggestions as to gems to appear on this page. Here is the latest from Ted Merrill. He writes with a send-off from Alexander Pope, " 'From wine what sudden friendship springs.' . . . French wine subsidies have piled up so much ethyl alcohol in government stores that diplomatic maneuvering is underway to sell it to Germany as fodder for synthetic rubber plants. Pressure to get rid of the surplus may overcome opposition to the re-establishment of German synthetic production which has been banned by the Allied Powers Agreement since World War II. The pending arrangement brings out the intriguing possibility of German tire manufacturers advertising 'Best Grade Rubber, Vintage '49'."

T. C. Du Mond
Editor